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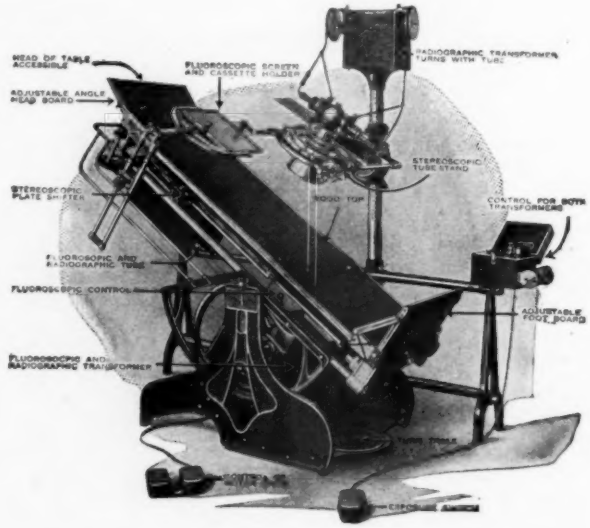


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THE AMERICAN JOURNAL OF ROENTGENOLOGY

*Editor, H. M. Imboden, M.D., New York*

VOL. VIII (NEW SERIES) OCTOBER, 1921 10

# AN UNUSUAL CASE OF PULMONARY NEOPLASM*

By J. S. PRITCHARD, M.D.

Department of Diseases of the Chest, Battle Creek Sanitarium

BATTLE CREEK, MICHIGAN

ON June, 24, 1919, a student nurse, single, age twenty-three, was referred to my department for a chest examination on account of cough and blood-streaked sputum, associated with afternoon temperature of 100° to 101° and pulse of 96 to 108. These symptoms had existed for the past ten days.

Prior to the above history the patient had always been well except for the usual diseases of childhood and two abortive attacks of what simulated appendicitis. Nineteen months prior to the present indisposition the patient was carefully examined before entering the Nurses' Training School, which showed the following results:

*Family History.*—One brother had tuberculosis of the hip and made a satisfactory arrest.

*General Condition.*—Height 5 feet, 7 inches, weight 125 pounds, temperature 98°, pulse 84. Well developed, reflexes normal. No glandular enlargement; no abdominal tenderness. Pelvic examination revealed no abnormality. In the physical examination of the chest no cardiac or pulmonary irregularities were noted.

Fluoroscopic study of the chest revealed no abnormal diaphragmatic or cardiac irregularities in size, shape or movements, while the hilar shadows were reasonably normal.

*Laboratory Findings.*—Urine negative. Red blood count 3,800,000. Hemoglobin 85. White blood count 8,600. Wassermann negative. No respiratory symptoms.

The present symptoms, which occurred nineteen months after the original examination, were rather abrupt in onset, except that for the past two or three months the patient had noticed a slight tendency to cough. This symptom was often associated with what the patient described as "wheezes" in the throat. For the past ten days a slight cough, accompanied with some blood-tinged expectoration and an afternoon temperature of 99.2° to 100° F., had been present.

Physical examination of the chest revealed moist râles over the front and back of the right hilum. Fluoroscopic study showed an enlarged right lung-root shadow. Stereo plates revealed a small, distinct, clean-cut, rounded shadow in the upper part of the right lung root. This shadow measured 3.5 cm. in width and was spheroidal in shape (Fig. 1). Sputum contained no acid-fast bacilli or elastic tissue. Wassermann negative. Complement fixation test for T.B. negative. No leukocytosis or eosinophilia.

The patient was placed on absolute rest treatment and all symptoms subsided rapidly, entirely disappearing in two weeks or approximately four weeks from the appear-

*Report of a case presented before the Kent County Medical Society, Grand Rapids, Mich., April 13, 1921.

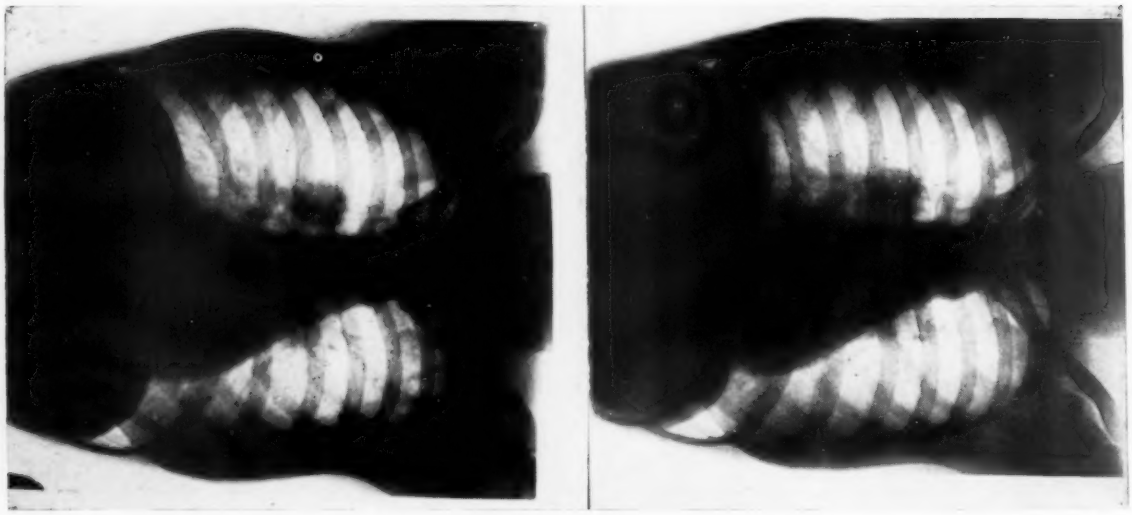


FIG. 1. Stereo plates showing a small rounded sh dow in the upper part of the right lung root.

ance of the first symptoms. The patient resumed her duties as pupil-nurse and worked steadily without interruption or indisposition, except for a slight unproductive cough, until April 7, 1920, a period of nearly ten months, when she had a recurrence of her former symptoms. These again disappeared after ten days' rest in bed. Stereo plates at this time showed that the right hilar shadow had about doubled in size (7 x7¼ cm.; Fig. 2). A few sibilant râles were heard over the corresponding surface area in front. No leukocytosis. No eosinophilia. Complement fixation for T.B. negative. Complement fixation with Wineberg's antigen for echinococcic infection negative. Wassermann negative. No acid-fast bacilli were found in the sputum.

On July 2, 1920, the patient resumed her duties and remained free from symptoms and apparently well, except for a slight cough, for the next ten weeks. A moderate hemoptysis occurred a few nights later, followed by a decided rise in temperature (104° F.). Three weeks' rest in bed resulted in the disappearance of the symptoms, and

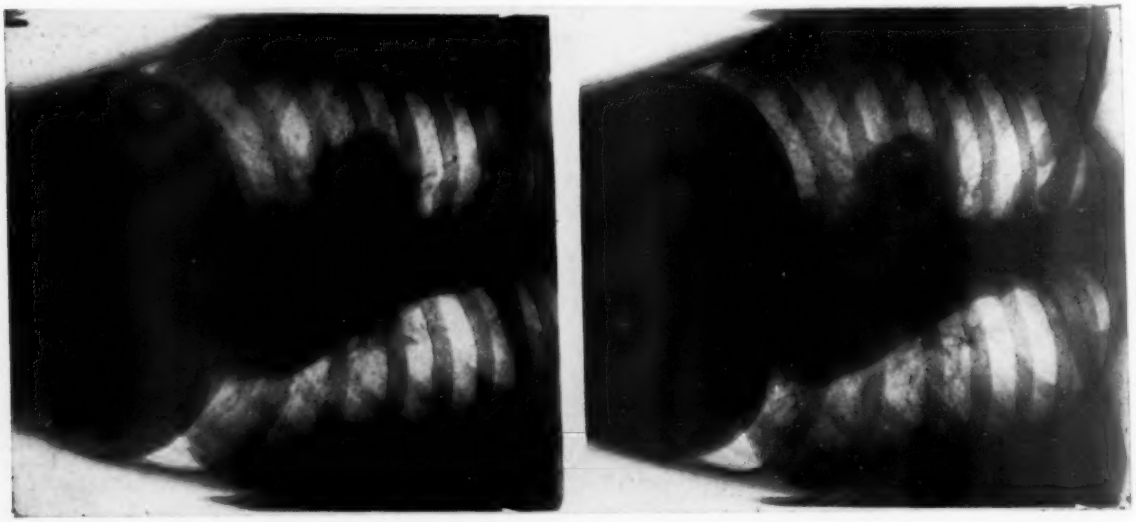


FIG. 2. Stereo plates taken ten months later, showing increase in the abnormal shadow.

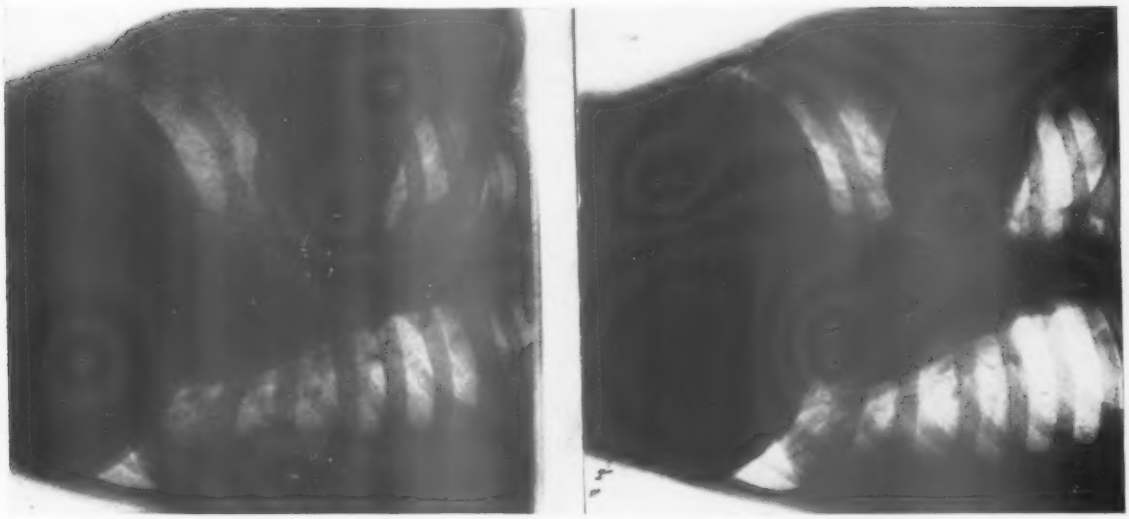


FIG. 3. Stereo plates taken ten weeks later, showing an extension of the pathology to the pleura.

another investigation at this time showed a definite increase in the thoracic growth, it now measuring 12 cm. across and 10 cm. on a vertical plane and extending to the pleura (Fig.3). The râles had correspondingly increased in area.

After the third attack, the patient went home and rested for a while, returning about the middle of September, 1920. Two months later she was again referred to me on account of an increased pulse rate, fever and expectoration. An examination showed the pulmonary pathology had increased to such an extent as to occupy most of the right thorax except the apex and the costophrenic angle (Fig. 4).

After some subsidence in the clinical symptoms, the patient was sent to Dr. Emil Beck of Chicago for an opinion relative to surgical interference.

Up to this time, sixteen months after the initial attack, we were not able to make a diagnosis, but gave the following opinion: "We are unable to determine the type of chest pathology but advise surgical interference." Dr. Beck carefully studied the case

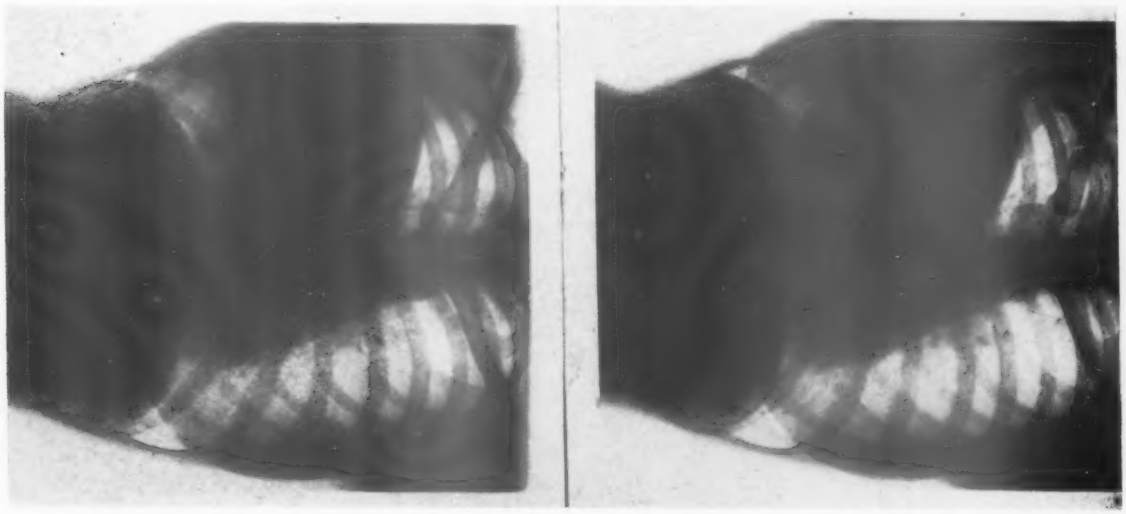


FIG. 4. These plates were taken eight weeks later or about fifteen months after the first roentgen-ray findings (Fig. 1).

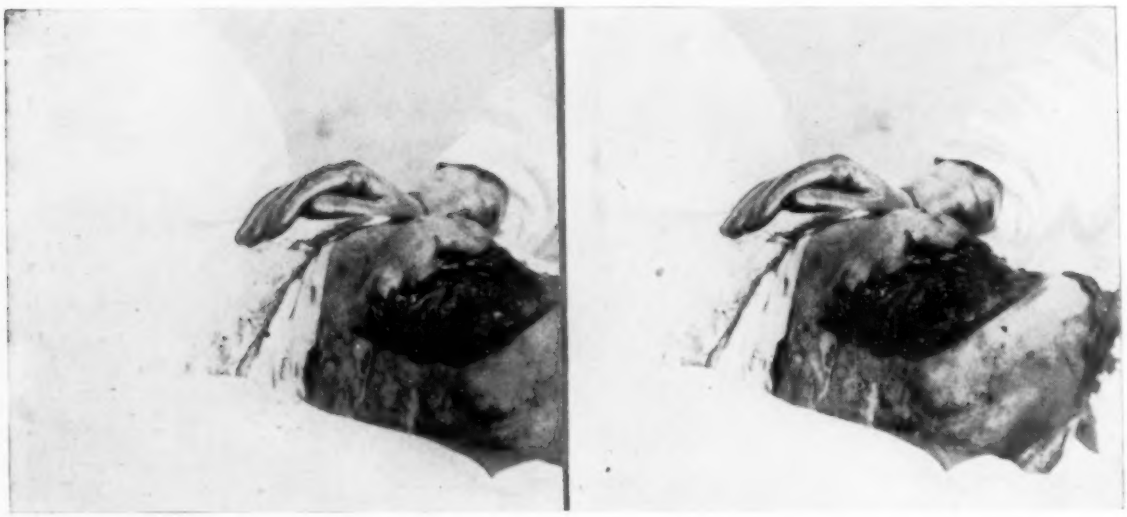


FIG. 5. Six inches of the fifth, sixth and seventh ribs was resected and silver nitrate applied to pleural surfaces, so as to secure adhesion.

and agreed that surgery was imperative. He operated on the case on October 15, 1920, first resecting about 6 inches of the fifth, sixth, and seventh ribs overlying the tumor and leaving the entire wound exposed and the skin flap rolled up for three days (Fig. 5). In order to obtain an adhesion between the pleura and the tumor, silver nitrate was applied to the entire area and surrounded with vaseline gauze. At the end of the third day, the operation was continued and a purse-string suture was placed in the tumor mass to prevent hemorrhage. On opening the growth, a mass of semi-solid consistency resembling a myeloid tumor or soft sarcoma was revealed. The entire sac was evacuated, the contents weighing about 800 gm. (Fig.6).

*Pathological Examination.*—Specimens of the tumor were sent to Dr. A. S. Warthin, Dr. Ludwig Hektoen and Dr. William Carpenter McCarthy. All reported a diagnosis of spindle cell sarcoma.

The tumor cavity (Fig. 7) was found

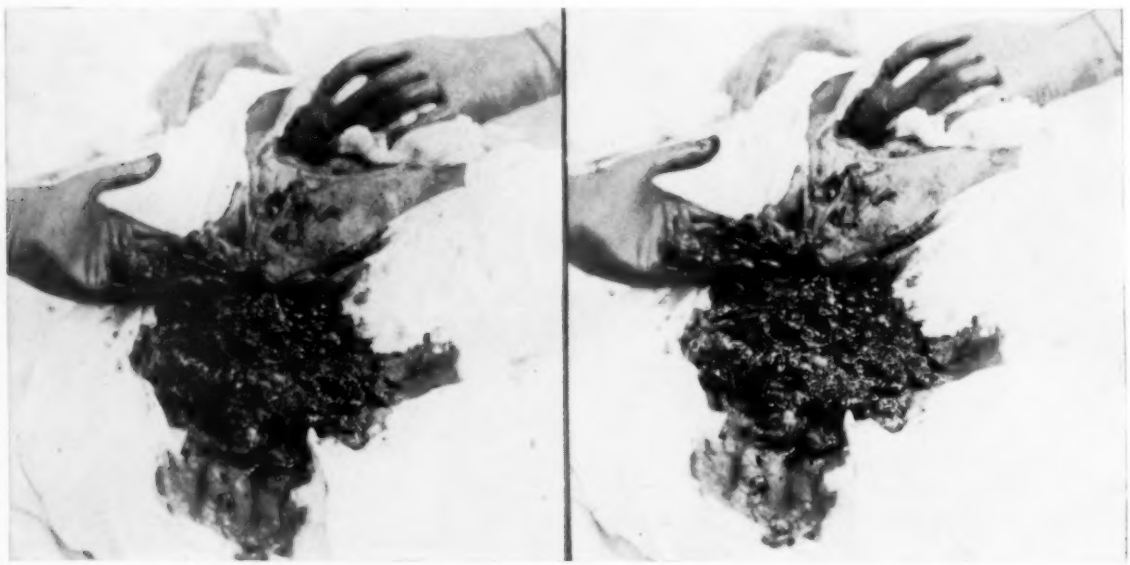


FIG. 6. Entire contents of sac was evacuated.

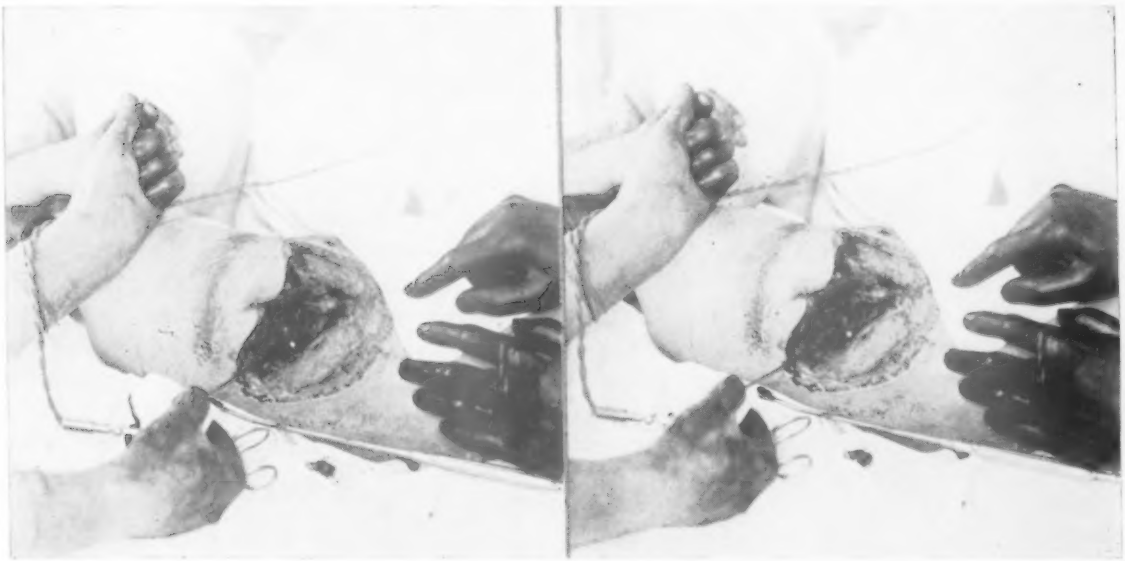


FIG. 7. The cavity was found to communicate with a bronchus.

to communicate with the bronchus, and the occasional opening of this probably accounted for the periodical respiratory symptoms, which were followed by a cessation of the same for long periods of time.

Three weeks after the operation, the patient was walking around the hospital and had a good appetite, having gained some 6 pounds in weight. Radium was applied to the inside of the cavity, and after regaining her normal weight the patient returned to Battle Creek, where the radium applications were continued.

The patient remained well until April 1st, when she developed an afternoon temperature of about 100° F. This was the first indisposition since the operation.

Examination showed no evidence of thoracic tumor, but an attempt at reconstruction of the resected ribs was in evidence (roentgen ray). During all this time the cavity was dressed daily and drainage encouraged.

On account of present symptoms, Dr. Case took sections of the tissue in the cavity wall for examination, on which Dr. Warthin reported no malignancy, but a pyogenic infection, from which the patient is suffering at the present time.

Interesting data on the above described case:

(1) Unique onset.

(2) Irregularity of the symptom-complex accompanied by long intervals of practically normal health. This manifestation was undoubtedly influenced by the presence of the small bronchial fistula which opened at intervals when the pressure within the tumor reached its maximum.

(3) The length of time elapsing between the initial attack and the operation (sixteen months) and the physical capability of the patient to complete the last half of her three years' course in the Nurses' Training School.

(4) The similarity of the attacks in this case and those found in many cases of pulmonary tuberculosis.

(5) The similarity of the roentgen-ray findings with those of some cystic formations.

(6) The lack of physical deficiency, such as loss of weight and strength during the sixteen months of tumor development and partial destruction.

(7) The very rapid recovery after surgical interference.

NOTE. Since reporting this case, Dr. Emil Beck resected the free ends of the divided ribs, thereby improving drainage, and the patient returned free of symptoms. For the past two months she has been at work (September 6, 1921).

# DUNHAM'S FANS IN A ROENTGEN-RAY STUDY OF GRANITE DUST INHALATION

By D. C. JARVIS, M.D.

BARRE, VERMONT

INTRODUCTION.—If there is any one phase of lung pathology that impresses itself upon the observer in a roentgen-ray study such as the above, it is the occurrence of Dunham's fans. One cannot see them appear from day to day upon the roentgen-ray films as the examining work progresses without being compelled to admit to himself that they represent pathology. Their uniform shape and situation cause one to study them, and after observations to make deductions and draw conclusions as to their method of production, the reason for their appearance and the significance of their presence. In examining hundreds of granite cutters, one is able to select a certain part of the lung in which a fan is commonly seen, lay aside all such films, and then have the pleasure of studying the change in density of the fan area, the increase in size, and finally the progression of the lesion in this area to the point where the original fan is lost in the ever increasing size of the density, increasing in the same manner as a river overflowing its bank.

*Dunham's Work.*—The writer owes a great debt to Dr. Kennon Dunham of Cincinnati, Ohio, for exploring lung pathology and demonstrating its connection with the shadows seen upon the roentgen-ray film. Without his having blazed the trail, this study would have been impossible. Dunham, in 1917, in his work on stereoroentgenography, entitled "Pulmonary Tuberculosis," called attention to the fact that the roentgen ray had its limitations. He laid emphasis upon the fact that a carefully taken history and a thorough physical examination were of the utmost value. At this time he also called attention to the fact that the tree-like shadows seen upon the normal chest plate were due to blood-vessels, bronchi and connective tissue, each tree-like shadow being a composite of these three factors, but that of the three factors two were constant and one was variable. Of these three the connective tissue, which represented the variable factor, was the most important, and upon the amount present depended the density of the shadow. Attention was called to the fact that heavy trunks in themselves occurred in other diseases and did not of themselves justify a diagnosis of tuberculosis. Mention was made of the fact that a plate having a homogeneous distribution of its markings was not tuberculosis; that the most striking characteristics of the tuberculous picture are the variations of density change beyond the different group trunks, in contrast to the general homogeneous change of other diseases which might simulate tuberculosis. While all these points were emphasized by Dunham, the study of dust inhalation in the granite industry by means of the roentgen ray brings them to mind again, especially when it is possible by means of a mechanical irritant to produce films paralleling tuberculosis, bronchopneumonia and lobar pneumonia.

*Lung Zones.*—Dunham has divided the lung field from the sternum outward into three zones. These zones are arcs of a sphere extending from clavicle to diaphragm, and correspond to thirds of the lung field. They have been called respectively the hilum zone, mid-zone, and peripheral zone. Corresponding to these zones we notice the three sets of divisions of the bronchial tree. At the hilus we notice in the hilus zone the root divisions of the bronchial tree with trunks which are seen in the mid-zone of the lung. These trunks divide into branches, and the branches into twigs. The branches lie mostly in the mid-zone area of the lung, while the twigs lie wholly in the peripheral lung zone.

*Situation of Fans in Pneumoconiosis.*—One notices first of all a tendency to the formation of Dunham's fans in the branches of the first and second interspace trunks; that is, they are more commonly seen in these situations, but they occur in the whole lung field from the first interspace trunk to the base, it being possible apparently for the lung field to contain five of these fans at the same time, and as this consumes the lung field area from clavicle to base, no room existing between the fans for the formation of another, it would appear that no greater number than five is possible. These have all their bases toward the pleura and their apices toward the hilus.

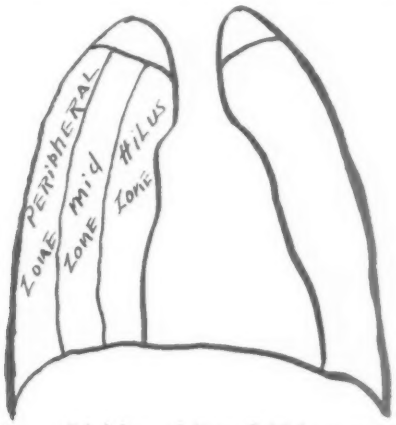



FIG. 1. Division of lung field into zones.

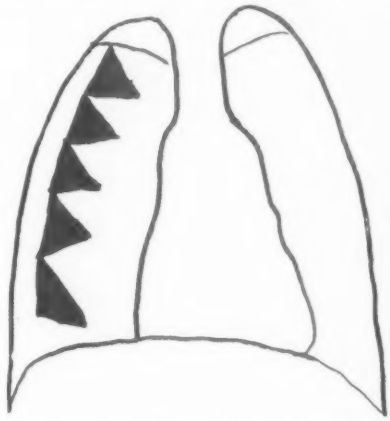


FIG. 2. Five fans, taking up all of lung, extend from above downward. Lowest fan points toward diaphragm.

*The Visualization of Lymph Nodules at the Divisions of the Bronchial Tree.*—In searching the lung field for a visualization of Miller's secondary lobules, we discover three sets of areas of increased densities, which one might term proximal, medial and distal, situated respectively in the hilus zone, mid-zone and peripheral zone of the lung field. These areas are not seen at one and the same time unless the reception of irritant at the lung periphery by way of the bronchi has been so great and has extended over such length of time, as to make the functioning of these areas necessary to receive irritating material passing over a blocked lymphatic system on its way back to the tracheobronchial lymph nodes. Krause, in a recent number of *The American Review of Tuberculosis,* has shown that the pathological process in a lymph nodule is dependent upon the behavior of the lesion situated peripheral to it. These areas which have been mentioned are adjacent in the hilus zone to a circular area of lessened density surrounded by a thin white line, the whole representing a lymph nodule and a branch of the bronchial tree, the bronchus appearing as if seen on end and the lymph nodule appearing like the end of a cotton wound applicator. The reason, it is felt, that this area represents a lymph nodule is because in the chest of the same cutter, by means of serial films, they are seen disappearing during a strike lasting ten weeks, only to reappear when work was resumed. If these areas always represented a calcified gland, could they fill, empty and refill all within the space of nine months? Now, using one of these proximal lymph nodules, as we shall call them, for an apex of a triangular area, we shall find the base formed by two medial nodules of the same character. In turn, using one of these medial nodules for an apex, we shall again see the base of a triangular area formed by two lymph nodules, but this time they will be those of the distal set. The sides of these triangles are formed by linear densities. From these triangular areas, which at first contain the lung markings seen in the lung as a whole, we see Dunham's fans develop. The lung pathology from granite dust inhalation being fine in its beginnings and generalized

in its distribution, its very slowness of development allows the evolution of a fan to be studied in the same individual by means of serial films.

*Evolution of a Fan.*—Let us then describe the evolution of a fan of the right interspace trunk. With our hilus as a starting point,we notice extending out from it an area of increased density. This area may be likened to a roadway as reproduced on the map of a city. The roadway extends to a medial lymph nodule which may be considered a junction of two other roadways coming in from the lung periphery, and from this junction these two roadways diverge in a fan-shaped manner, each roadway ending in a distal lymph nodule. We then have a triangular area similar to the Flatiron Building in New York, enclosed by lines of increased density, which we liken to the roadway around this building. Now, if we examine these lines of increased density, we shall discover on their inner side an area of increased radiability which follows closely along what we have termed a roadway. We might compare this area to the sidewalk, only it is like a sidewalk at night, because while we know it is there we cannot see it on account of the darkness. There is, however, a fine white line on the inner side of this sidewalk area which helps us in our orientation. Now, supposing this triangular area within the roadway and sidewalk was represented by a vacant lot, and people were being brought constantly to this area by a subway, what would happen? We should expect the congestion in the roadway and sidewalk to become so great that in a short time the vacant lot would be occupied by people, and if it was looked down upon from an aeroplane it would appear black compared with the surrounding country, because of abnormal activity in this particular area. A time would arrive when some desired to leave this area, and then the surface methods of transportation would be called into activity greater than that represented by normal traffic. If the lines of transportation were efficient, the triangular area would maintain its original size; if not, there would be an overflow into the surrounding territory, and when now viewed from an aeroplane the black area would have increased in size. Supposing the crowd were represented by men only, then we should have no increase in numbers other than from incoming traffic; but supposing both sexes were represented, in time the numbers would increase by means other than incoming traffic. By means of this homely illustration an endeavor has been made to describe lung pathology as seen in the making, by means of a roentgen-ray film, and the very important part Dunham's fans play in its evolution. If we analyze this illustration we shall discover that the roadways represent the arteries about which we have connective tissue formation. The sidewalks are branches of the bronchial tree; the crowd of men represents our mechanical irritant, such as granite dust, and the crowd of both sexes our bacterial irritant. The mechanical irritant entering by way of the bronchi is received at the lung periphery and leaves the lung in part by passing back toward the hilus by means of the lymphatic system, while the bacterial irritant, if of sufficient virulence, or if the lymphatic system is slow in filtering it through, proliferates in the periphery or along the lymphatic pathway and causes a lesion there.

Let us call the bacterial irritant of high virulence tuberculosis, lobar pneumonia, or whatever you wish, and the mechanical irritant pneumoconiosis, or whatever you wish. The bronchial tract we can liken to the subway and the lymphatic system to the surface cars, and the reason, it is felt, that we visualize the fan-shaped area on the roentgen-ray film is because there is lack of air in the triangular area, producing naturally an area of greater density.

*Varieties of Fans.*—There are apparently two varieties of Dunham's fans, the large and the small, the first being most often seen in pneumoconiosis and the second in tuberculosis. The term "fan" having been used most often in conjunction with the subject of

tuberculosis from a roentgen-ray standpoint, it doubtless has been inferred that it was a pathognomonic sign of tuberculosis; but Dr. Dunham's own interpretation of fans as given by him to me is as follows: "Fans when seen upon the *x*-ray film are characteristic of a lung lesion but not necessarily characteristic of tuberculosis. The fan of pneumoconiosis is larger and lies in the midzone of the lung field with lung pathology in the form of increased densities lying between it and the hilus. The characteristic fan of tuberculosis is small in size, lies near the pleura in the peripheral zone of the lung and is accompanied by a definite apical lesion."

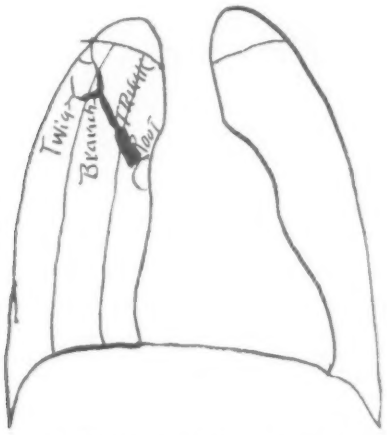



FIG. 3. Divisions of linear markings.

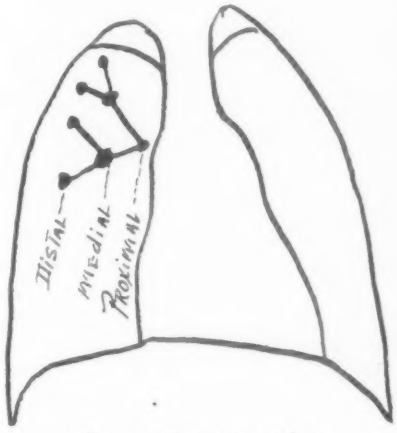



FIG. 4. Showing nodes.

*Significance of Appearance.*—What then do fans suggest to us when viewing the roentgen-ray film? Apparently, by means of serial films, we are able to demonstrate in granite cutters five stages of pathology witnessed on the films as follows: (1) Increase in hilus width and density, giving evidence of continued drainage of an irritant through the lymphatics from the periphery back to the tracheobronchial lymph-nodes. (2) Increased width and density of trunk markings, giving evidence of hyperplasia, from the passing of the irritant through the lymphatics. (3) The appearance of lung densities in the situation of the lymph nodules at the branching of the bronchi, these nodules taking on their function the same as the cervical glands take on theirs. (4) The appearance of fans giving evidence of an accumulation of more irritant at the periphery than the lymphatics draining that particular area can drain back to the tracheobronchial lymph-nodes. (5) The appearance of a homogeneous haze at the lung periphery pleural level, giving evidence that the work of draining the irritant back to the tracheobronchial lymph-nodes has become too great, consequently a détour is being made through the pleural lymphatics. It will be seen that fans represent one of the later stages of lung pathology when seen in a dust worker, and indicate a much-needed absence from the occupation in order that the lung may have the oportunity of clearing itself, which it makes a strenuous effort to do when given the chance. To the student in economics it indicates a much-needed system of dust-removing devices in order that the health of these dust workers be preserved and lung pathology, which produces a physiological disability, be avoided. It seems like tempting fate to interpret the causal factor of lung densities when viewing a roentgen-ray film, because by means of a mechanical irritant such as granite dust, it takes a granite cutter thirty years to produce a lung lesion which would be diagnosed if he had constitutional symptoms such as lobar pneumonia. It takes him between twenty and twenty-five years to produce a lung lesion which would be

diagnosed as bronchopneumonia if he had constitutional symptoms, and ten to fifteen years to produce a condition which would be diagnosed as tuberculosis if he had constitutional symptoms. In addition, his films may duplicate carcinomatosis and post-influenzal conditions, all without constitutional symptoms. One can imagine the difficulties awaiting the roentgenologist who endeavors to interpret the causal factor from the evidence obtained from the roentgen-ray film alone. All the granite cutters referred to were *x*-rayed, not because they were ill but because their Union voted to cooperate in the examining work to the extent that each cutter appear for examination in order that some idea might be gained as to the effect of granite dust inhalation on his lungs. They were all working and considered themselves in good health. It would then seem that the roentgenologist is justified in reporting back lung densities, but that the clinician should assume the burden of proving whether the causal factor of the lung densities is mechanical, chemical or bacterial.

SUMMARY

1. Dunham in his work on "Pulmonary Tuberculosis" emphasized the limits of the roentgen ray in chest work, but the roentgenologist is at times apt to forget these limitations.

2. In the interest of efficiency it would seem advisable to retain Dunham's terminology.

3. Dunham's fans may be seen in pneumoconiosis situated unilaterally, bilaterally, or in any part of the lung.

4. Their formation is one of blocking of the lymphatics by the irritant in question, producing hyperplasia as a result of its passing through them.

5. They represent the fourth stage of lung pathology in the making, as its progress is noted by means of the roentgen-ray film.

6. It would seem that the proving of the causal factor of these fans, whether mechanical, chemical, or bacterial, should be assumed by the clinician, the roentgenologist reporting back only densities.

# REPORT OF A CASE OF OSTEOSARCOMA*

By L. B. MORRISON, M.D.

BOSTON, MASSACHUSETTS

MALIGNANCY, whether in early childhood, during the period of adolescence, or in adult life, has always stalked the medical profession like an insatiable monster, ready to devour and destroy life. Any method is sought to destroy it which does not entail too much suffering. To one constantly dealing with malignant disease comes the oft-repeated phrase from an anxious parent, husband or wife: "Can't something more be done, Doctor?" We eagerly turn to surgery, which has accomplished so much in this and other fields, but it still fails to fill the gap. In the early stages of malignancy, surgery is the method of choice, but there are the pitiful cases of a malignancy too long undiscovered or too rapid in onset and so located that the word "inoperable" is pronounced with all its menace of impending disaster, depicting the helplessness of the surgeon. By the use of the roentgen ray and radium a brighter future can be assured to many cases of this type. Many can be given weeks, months and even years of useful existence when otherwise only a life of misery shortened by death is the inevitable ending. In this day of efficiency, every patient, whether afflicted with arthritis, tuberculosis, chronic heart disease, malignancy, etc., should not only be made as free from suffering as possible but made as efficient as possible, so that he or she may, in part at least, earn a living and be made a producer. It is always worth while to do everything possible in these malignant cases, because frequently most surprising results are obtained. Any evidence of peculiarity in the behavior of a case may be the stepping stone to future successful treatment.

I wish to report the following case of osteosarcoma of the left femur in a young girl whose parents would not submit to radical surgery. The growth was rapid and emaciation extreme. The case was referred to me for roentgen therapy by Dr. Mark Rogers of Boston.

Miss G. M., aged fourteen, of previous good health and with no history of injury, during the month of November, 1918, began to have pain in the left leg and knee, severe enough to awaken her at night. She lost weight rapidly and became emaciated, weighing about 75 pounds, previous weight 116 pounds. A roentgenogram was taken at the New England Deaconess Hospital, Boston, and a diagnosis of sarcoma made. An exploratory operation was performed by the attending surgeon, December 20, 1918, to verify the roentgen-ray diagnosis. Amputation was advised, but the parents would not consider amputation. A small section was taken from the growth and the report of the pathologist follows:

*Copy of Pathological Report. G. M.*

Specimen from femur received December 30, 1918.

A piece of bony tissue about 1½ inches long and ¼ inch thick. Microscopic examination shows the tissue to consist essentially of a meshwork of osteoid tissue, the interstices of which are filled with connective tissue or a generally cell-rich tissue. This cell-rich tissue in places contains many vacuolated cells suggesting undifferentiated cartilage cells and osteoblasts. In a few places the osteoid tissue gives place to cartilage.

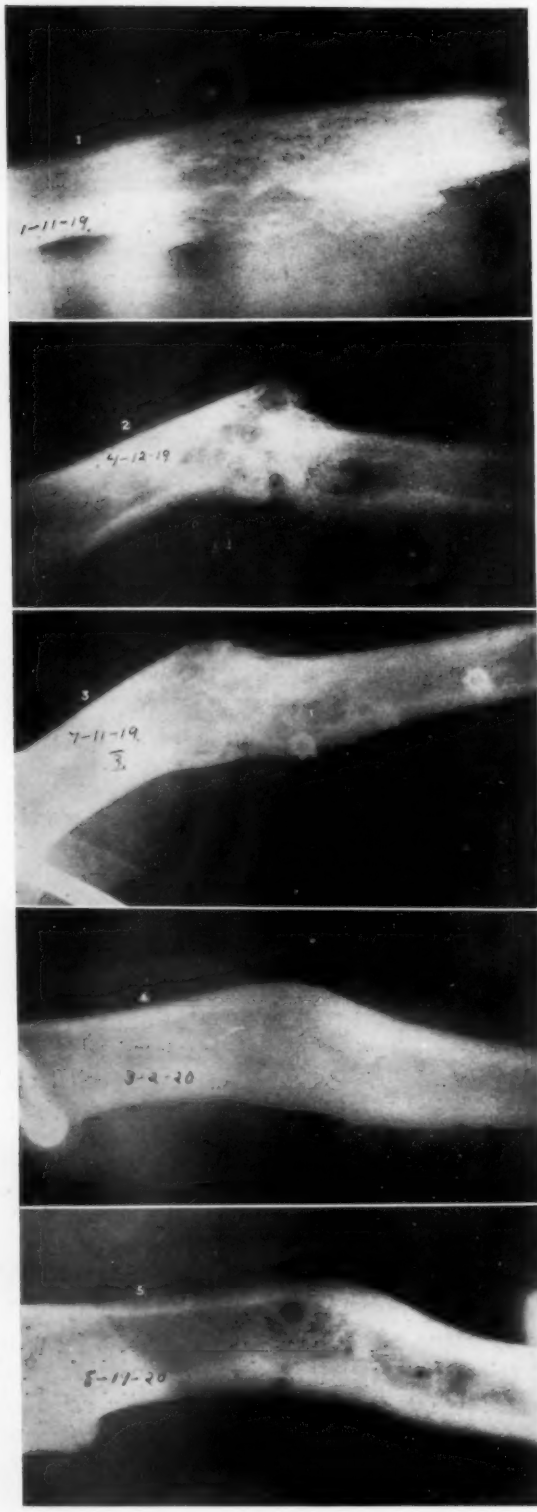
Diagnosis: Osteosarcoma.

Reference number: 18-585. (signed) J. Homer Wright.

Just how malignant this type of sarcoma is must be judged somewhat by the rapid involvement of the femur in the eight to nine weeks after onset and from the pathological report that speaks of a "*generally cell-rich tissue.*" Adami[1] describes the indication of malignancy in sarcoma as follows: "The

[1]Principles of Pathology, Philadelphia, 1908, Vol. I, Chap. xx, p. 700.

*Thesis presented with application for membership in THE AMERICAN ROENTGEN RAY SOCIETY.




FIGS. 1, 2, 3, 4 and 5 illustrate the change in the bone. The small round shadows seen in Fig. 5 are artifacts. Stereoscopic plates taken September 19, 1920, show a perfect medullary cavity and no periostitis.

tissue of origin, if it can be determined, should largely influence our diagnosis. At most, we can lay down that the more embryonic the type of cell the greater the presumptive evidence of malignancy, and that as between two tumors of the same origin the more vegetative the type of cell and the greater the departure from the adult cell standard, the greater is the malignancy."

The patient came to my office January 14, 1919. Upon examination the mass on the femur could be easily palpated This was due to the emaciation and size of the growth. The infiltration in the soft tissues seemed to involve the upper third of the femur, below the lesser trochanter. Plate taken at this time shows an area of involvement of the left femur, starting 5 cm. below the lesser trochanter and involving 12 cm. in which the shaft, both medullary and cortical, is nearly destroyed; there was also considerable proliferation of the periosteum, particularly on the inner side. The bone was mottled and there were areas of rarefaction and areas of density showing new bone formation. Treatment was instituted, cross-firing through as many portals of entry as possible, using an 8½ inch spark gap with 3 mm. of aluminum for filters and using a 10 inch anode distance. The pubic and inguinal regions were also cross-fired. A full dose was given over each area. Soon after this treatment there was a pathological fracture at the site of the growth and the leg was placed in a Thomas splint. The patient was unable to be brought in for treatment until April 12, 1919, when treatment was repeated. The patient was next seen and treated July 11, 1919; at this time there had been a metastasis in the left frontal and right occipital regions of the skull, large, hard masses about 2½ to 3 cm. in diameter. The local physician had incised the frontal area and bloody exudate was found. Treatment was instituted over the skull sufficient to cause epilation. At this observation there was a slight dermatitis over the thigh with marked brown pigmentation. Plates were taken and treatments continued at intervals until June 1, 1920, showing gradations of healing, until at the present time

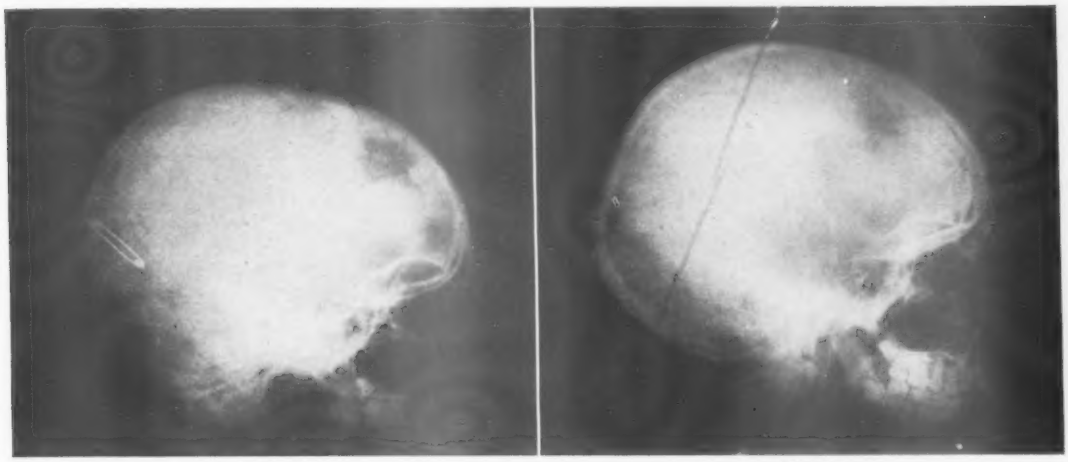


FIG. 6. FIG. 7.

FIG. 6. Taken July 11, 1919; shows an irregular area of bone destruction in the left frontal from a metastatic growth; the area in the occiput does not show, it is seen only in the anteroposterior view.

FIG. 7. Taken December 1, 1919; shows the healing process well started and shows the margin of the occipital area.

there is no evidence of malignancy seen in the femur. All induration has left about the areas in the skull and the area in the left frontal seems healed. As yet the regenerated bone is not quite as dense as the surrounding bone. The area in the occiput is about two-thirds healed. A careful examination of the skull, chest, abdomen and extremities made August 19, 1920, fails to reveal any evidence of a recurrence otherwise than noted. The patient is well, and is having no symptoms of a pathological process at the present time.

It is interesting to note that the lesion in the thigh was operated on and a small portion removed for examination, though no attempt to eradicate the disease was made, and later there was a traumatic fracture. The lesion in the left frontal was incised and drained, while the lesion in the occiput had no surgical interference, and with the same dosage applied here as over the frontal, healing is slower. Whether this is just a coincidence, or whether there is definite value in enough surgical interference to set up an acute, inflammatory process before giving

FIG. 8. FIG. 9.

FIG. 8. Taken March 2, 1920; shows the frontal area nearly healed and the area in the occiput.

FIG. 9. Taken May 23, 1920; shows the frontal area nearly healed except in the central portion, and brings out the larger area of the occipital growth.

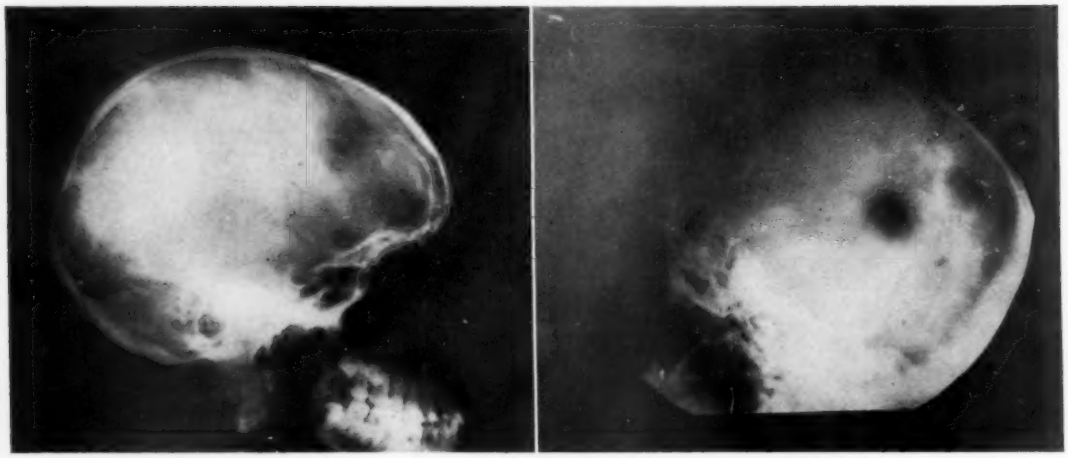


FIG. 10. FIG. 11.

FIGS. 10 and 11, taken August 19, 1920, show the frontal area practically healed and the slower healing margins of the occipital growth.

FIG. 11. Taken August 19, 1920; shows the healing margins of the occipital growth.

treatment, I am unable to state. This one case suggests it.

In my review of the literature, although it has not been exhaustive, I have been unable to discover similar cases. I report this case to illustrate the value of roentgen therapy in these seemingly extreme cases, and also to indicate the possible value of sufficient surgical interference in sarcoma to set up an acute inflammatory process before treatment is instituted, realizing that the surgical rule is high amputation and non-interference with the growth for fear of transplantation or metastasis.

# EXTRA BONES IN THE WRIST AND ANKLE FOUND BY ROENTGEN RAYS

By A. HOWARD PIRIE, M.D.

MONTREAL, CANADA

THERE are certain extra bones in the wrist and ankle which appear fairly frequently in roentgenograms and should be familiar to surgeons and roentgenologists. There are others that are moderately rare and still others that are very rare.

The object of this paper is to state my experience as a roentgenologist regarding these extra bones.

There are no extra bones in the hand that can be said to appear often in roentgenograms, but in the foot there are a few fairly common, viz., the os trigonum, the tibiale externum, secondary os calcis, os peroneum, and another extra bone without a name.

In the hand there are two extra bones which may be considered moderately rare, viz., the os centrale and the os triangulare. All the other extra bones are very rare.

Roentgenologists examine many more wrists and ankles than anatomists do, and it is not surprising that extra bones considered rare by anatomists should be found fairly often by roentgen rays.

Knowing and recognizing these extra bones become important when the question of fracture arises and an extra bone is found to be present. It has an even greater medico-legal interest when an extra bone is found in a case of suspected fracture. I have seen such a bone and a fracture lying side by side and have been able to prove that the extra bone was not part of the fracture by examining the other wrist and finding the extra bone present in it also.

One is asked what these extra bones represent. A few of them are explained by comparative anatomy; for instance, the os centrale in the wrist is a constant bone in lower animals right up to the monkey. Another more general explanation is that in the embryo there are many more centers found for bones than are found in the adult, and that during development these fuse together to form the normal number of bones in the wrist and ankle, but occasionally one center persists and ossifies, forming an extra bone. I lately examined a fossil of a saurian in which the wrist was represented by many more than the usual number of bones. The extra bones found in the wrist of man may be the analogues of these.

Extra bones which are found separate at times are found in other cases united to other bones. An example of this is seen when the styloid of the ulna is unusually long. This extra length is caused by the fusion of an extra bone, the os triangulare, to the tip of the styloid.

Sesamoid bones are in the same class as the extra bones and great variation is found in the sesamoid bones of the hand and foot. Sesamoid bones are much more common in the fetus than in the adult. Most sesamoids have no function and are found where they are in order to get rid of them.

About twenty extra bones have been described in the wrist. The full list can be found in the last edition of Quain's "Anatomy." I shall confine myself to those of which I have had personal experience, viz., in the wrist: (1) os centrale; (2) os triangulare; (3) ulnare externum; (4) radiale externum; (5) os vesalianum, and (6) divided scaphoid.

Taking first the os centrale (Fig. 1). A variation of this shows the os magnum with a projection on it which represents the os centrale fused to the os magnum. In other cases one sees a space between the os magnum and the distal part of the scaphoid, at one time probably occupied by the os centrale, which has disappeared and its place been taken by fibrous tissue. The os centrale is found constant in monkeys as one of the bones of the wrist.

The os triangulare is found in 65 per cent of second month embryos, but it is moder-

FIG. 1. Os centrale.

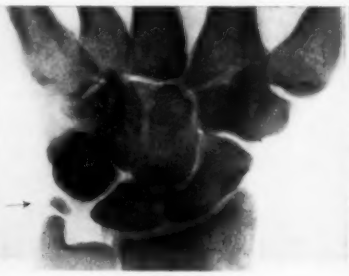


FIG. 2. Os triangulare.

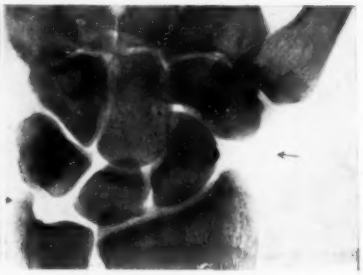


FIG. 3. Long styloid due to fusion of os triangulare.

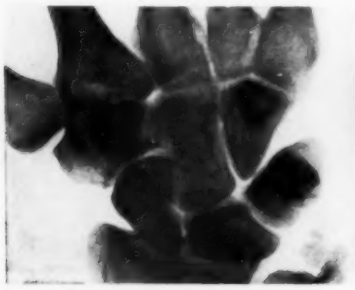


FIG. 4. Fractured styloid and os triangulare.

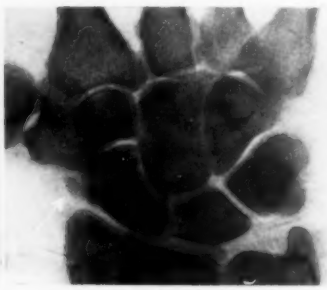


FIG. 5. Radiale externum.

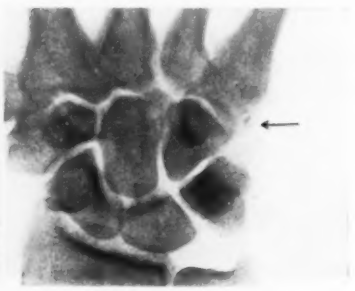


FIG. 6. Os vesalianum.

FIG. 7. Thickening in semilunar.

FIG. 8. Os trigonum.

FIG. 9. Secondary os calcis.

ately rare in the adult (Fig.2). It is a perfectly formed little bone like a sesamoid. It must not be confused with a fractured styloid. In the latter the rough edge of the fracture is evident. In old cases of fracture the rough edge disappears, but the styloid remains deformed.

Examination of both wrists should be made when the presence of an extra bone is suspected, and if it is present on one side it will usually be found on the other side. Figure 3 shows an extra long styloid process. This appearance is caused by the fusion of the os triangulare with the styloid process. Fracture of the styloid process is very common, but a true os triangulare is moderately rare. Comparison of right and left wrists easily settles the question when one wrist only has been injured. Figure 4 shows a fractured styloid and an os triangulare.

The ulnare externum is a very rare bone in my experience. I have seen it only once. Figure 4 shows the only case I have seen. It lies between the fifth metacarpal, the unciform and the cuneiform.

The radiale externum is the end of the tubercle of the scaphoid. It is very generally found among mammals, but it is very rare in man. Figure 5 shows this bone present in the left hand. It was not present in the right hand, but in the right scaphoid the tubercle was larger than in the left, and this prom-

inence represented the fused radiale externum.

The os vesalianum is called after Vesalius, who described it as a normal sesamoid bone of the wrist. While examining a treatise on anatomy by Vesalius I found a diagram of this bone. I had thought that in studying these extra bones I was pursuing rather a new subject, but as Vesalius described this bone nearly three hundred years ago, I was forced to the conclusion that the subject was decidedly old and only neglected. Figure 6 shows the only specimen that I have found.

The divided scaphoid is frequently found in two parts. It may be in two parts at birth. The appearance of the scaphoid in roentgenograms is more varied than that of any other bone of the wrist. I have found many cases of it in two parts, but in all there was evidence of fracture. Comparison with the other side should be made when a divided scaphoid is suggested, and if it exists also in the other wrist without history of accident the diagnosis of divided scaphoid is justified.

These are all the extra bones in the wrist that I have found. At one time I thought I had found several others, but when examined stereoscopically it was found that what appeared to be an extra bone was really only a thickening inside a normal bone. Figure 7 shows an example of such a thickening in the semilunar. These thickenings may be the evidence of old healed tubercular disease and correspond to the small calcified spots so often seen in the lungs. I have found them in the scaphoid, pyramidal, and semilunar bones. They may be multiple.

In the foot the extra bones which I have found are as follows: (1) os trigonum; (2) secondary os calcis; (3) tibiale externum; (4) os peroneum; (5) os vesalianum, and (6) an ossicle with no name.

The os trigonum is said by Pfitzner to occur in 7 to 8 per cent of ankles. In roentgenograms it is quite as common as that. It is a constant bone in marsupials with five

FIG. 10. Tibiale externum.

FIG. 11. Os vesalianum.

toes. It is really the posterior external tubercle of the astragalus. It is by far the most frequently seen extra bone of the ankle. Figure 8 shows the os trigonum. It may be short and stout or long and slender.

The secondary os calcis is a small bone which is occasionally found in the angle between the os calcis, the astragalus and the scaphoid. Figure 9 shows a specimen of this bone. It corresponds to the os centrale in the hand.

The tibiale externum is found at the tuberosity of the scaphoid. It is a constant bone in many animals and is found in the second-month human embryo. Figure 10 shows a specimen of it. It is important for surgeons to be familiar with this bone as it looks like a fracture. It more frequently than not occurs on both sides. It is commoner in women than in men.

The os peroneum is a common bone. It lies in the tendon of the peroneus longus. I have seen it single, double, triple, quadruple, and multiple. Its position varies, but usually it is seen in a semilateral view lying between the os calcis and the scaphoid. It is present in Figure 8.

The os vesalianum is a very rare bone which occurs at the base of the fifth metacarpal and has to be distinguished from a fracture. This is best done by comparison with the bone of the other side. Figure 11 shows an os vesalianum. It is seen best in an anteroposterior view.

The last bone I have to mention is an ossicle with no name. I first noticed it five years ago and have been watching for it since. I now have 14 cases of it. I have found it in both feet in 4 cases. These are the only cases I have examined on both sides especially for this bone. After finding a few cases, I consulted the professor of anatomy in Edinburgh University and his answer was very interesting. He had never seen it, he had never heard of it, and after looking up the literature on accessory bones he could find no mention of it, but he was prepared to admit that it existed, as he had found its articular surface on the scaphoid in some cases. He promised to look out for it in the dissecting room and after a year he wrote to me and told me that he had found one . It therefore seems evident from these 14 cases which I have collected that this extra bone is not infrequently present at the posterior and upper part of the navicular as shown in Figure 12. I have one case in which it appears to be fused to the scaphoid and one in which it appears to be fused to the astragalus. Figure 13 shows the largest example of this bone I have found. It was present in the right and left foot and there

FIG. 12. Extra bone.

FIG. 13. Extra bone.

was no history of injury to account for its presence.

These are all the extra bones of which I have had personal experience except a few single specimens which I cannot name or speak further about until I find enough other specimens to place them in a category by themselves.

In order to find these few extra bones that I have mentioned I have examined an immense number of roentgenograms. I had special opportunity of doing this, as during the war I had to inspect all the roentgen-ray departments of the C. E. F. in England every three months and once those in France. During these visits the monotony of looking at fractures and foreign bodies was relieved by looking for extra bones, and after finding a few I kept on looking until now I have a representative collection of what an average roentgenologist may be expected to find.

RÉSUMÉ

About half a dozen extra bones occur occasionally in normal ankles and wrists. These have to be known and distinguished from fractures. This is best done by comparing the joint of the other side.

# PRIMARY SARCOMA OF THE VERTEBRAE*

## WITH REPORT OF FOUR CASES

By KARL F. KESMODEL, M.D.

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WASHINGTON, D. C.

PRIMARY tumors of the spine and cord are not rare, but primary sarcoma of the vertebrae is uncommon. Few cases were found in the literature. In an article by Roberts[1] he quotes Coley as finding only 12 cases of sarcoma in this region in a series of 12,000 cases.

The detection of this lesion is difficult, often missed, and often misinterpreted as tuberculosis of the spine. The presence of tuberculosis in the family of the patient is usually considered against neoplasm, but as shown by 2 of the cases reported, it should not legislate against the diagnosis of sarcoma, and, as Roberts states, sarcoma may appear in tuberculous subjects.

Age often plays an important part in diagnosis, as certain lesions most often occur in "age periods." But in sarcoma of the spine, age cannot be given undue consideration. It may occur from one year to seventy. Ewing[2] states that of thirty-one extra-dural spinal sarcomata one occurred between the ages of one and nine; three between ten and nineteen, none between twenty and twenty-nine; seven between thirty and thirty-nine; ten between forty and forty-nine; nine between fifty and fifty-nine; and one between sixty and sixty-nine. (This includes 81 cases tabulated by Schlesinger in 1898, many of the cases collected by Collins, and some recent reports up to 1915.) Of the cases reported by Roberts one occurred between the ages of one and nine; two between ten and nineteen; and one between fifty and fifty-nine. Of the cases reported here from the records of the Massachusetts General Hospital, one was between ten and nineteen years of age, one between forty and forty-nine, and two between fifty and fifty-nine.

A history of trauma frequently precedes the presence of the tumor. At times no history of trauma is obtained. In the cases of spinal tumors reported by Traube, Forster, Ollivier, Hunt and Woolsey[2] it is

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reported. In the cases reported here it will be noted in two, but in one it antedated the appearance of the neoplasm several years and may be discarded. Apparently trauma may be a direct exciting factor: it may hasten the rapidity of growth of a neoplasm already present, or it may have no association with it whatever.

Pain is a prominent symptom. It presents itself early and is severe. It may be local or referred along the course of the nerve emerging at the site of the tumor. It is usually unrelieved by immobilization. Considerable tenderness may be elicited at the site of the lesion.

Evidence of pressure at the roots of the peripheral nerves appears early in the disease. As previously stated, pain is a prominent symptom. Various sensory disturbances, such as anesthesia and paresthesia are noted. The sensation of touch and thermal changes may be absent in certain areas. Often there is a difference between the reflexes of the two sides, or they may be undisturbed or entirely absent on both sides. Oppenheim, clonus and Romberg may be obtained. There is muscular weakness with ataxia and atrophy.

Positive roentgenographic findings may be entirely absent. There may be no observable change in the outline or structure of the vertebrae to account for the symptoms and physical findings. When they are present, they are by no means characteristic. They are easily confused with tuberculosis, and it may be only by repeated examinations at frequent intervals showing the rapid destruction with the involvement of adjacent vertebrae, that a diagnosis may be derived. When changes in the vertebrae are observed, it is seen that although an adjacent one may be involved, the intervertebral space is lessened but little. In the cases seen at the Massachusetts General Hospital, it was noticed that the margins of the body were first attacked, adjacent vertebrae being involved, without the complete destruction of any. The destruction is irregular and the familiar "wedge-shaped" body is often missing. As a result, there is but little deformity in the vertical axis of the spinal column and the kyphosis ordinarily seen with the amount of destruction present is not observed. Abscess formation is absent, but invasion of the surrounding soft tissues by the new growth may simulate an abscess with calcification.

Sarcoma of the vertebrae must be differentiated from tuberculosis of the spine, spinal cord tumors, metastatic malignancy, fractures, syphilis and typhoid. Tuberculosis of the spine involves the joint early, destroying the intervertebral disc, whereas sarcoma first attacks the body. As a result, in the former condition the intervertebral space is lessened and eventually obliterated. In sarcoma the intervertebral space is affected but little. In neoplasms, adjacent vertebrae are soon involved without the complete destruction of any, but in Pott's disease the process is more localized and in the individual vertebra is more extensive. Kyphosis appears early in tuberculosis, but in neoplasm it appears late, after several vertebrae are involved, if at all. In the latter condition there is an invasion of the soft tissues which is not seen in the former, and the abscess so common in tuberculosis is absent in sarcoma.

The differentiation from primary tumors in the cord rests almost entirely on the radiographic findings. The clinical findings of the two are too closely allied for differentiation. If the tumor is primary in the cord, the changes seen in the vertebrae are due to pressure, not destruction, as seen in the true vertebral tumors. If the cord tumor is of the slow-growing type, a fusiform widening of the neural canal may be seen, or if of the more rapidly growing type, a distinct widening in a specific region with some erosion of the inner margins where the tumor passes out of the canal. In sarcoma of the vertebrae the outer margins of the body seem to be the first portion attacked, and, as previously stated, the lesion is primarily of the destructive type.

In metastatic malignancy of the spine, the lesion is always multiple when discovered and the primary lesion can usually be demonstrated. The location of the metastasis in

the individual vertebra is central, whereas the primary tumor usually appears at the margin.

In fractures of the vertebrae there is usually a history of a severe trauma, the deformity is of the compression type and there is no evidence of bone destruction. The fragmentation observed in some fractures of this region is not seen in neoplasms. However, should a fracture occur at the site of the tumor, the true lesion may be entirely missed.

Syphilis and typhoid of the spine can usually be ruled out by history and laboratory tests. The roentgenographic plate in these two conditions differs from that of the primary tumor in that the process is often accompanied by proliferative changes, bridging or actual ankylosis, and other evidence of repair which is absent in neoplasm.

The following 4 case histories are taken from the records of the Massachusetts General Hospital. All were proven at operation. I am indebted to Dr. M. S. Bringman, radiologist at the Massachusetts Homeopathic Hospital, for the privilege of reproducing the first roentgenogram of Case I, and to the Pathology Department of the Harvard Medical School for the privilege of roentgenographing an old specimen.

Case I (Hospital No. E.S. 249667). N. R. J. Female. Age, fifty-nine. Admitted January 9, 1921.

*Family History.*—One sister died of tuberculosis six years ago. The patient nursed this sister during her illness.

*Past History.*—Twenty years ago she fell down the stairs, injuring her spine. She had a spinal curvature afterward. About three years ago, just before her present illness, she became subject to frequency in urination.

*Present Illness.*—First symptom noticed was that she dragged her feet; then numbness appeared. This occurred about three years ago. The numbness ascended, reaching the level of the waist line, and she could not walk without falling over. She entered a hospital, and after being examined, including *x*-rays, she was told that "bones were pressing against the spinal cord." She was put in a plaster shell for six weeks, when the paralysis disappeared and she was able to walk. She was kept in the shell four weeks longer, then a corset was substituted. Shortly after the change her legs began to draw up and she could not straighten them out. The plaster jacket was again applied and in addition traction, this treatment continuing for three months. The plaster was then replaced by a leather jacket. Eighteen months ago she became suddenly paralyzed in both lower extremities, sensation being lost up to the waist. For the first time she had incontinence of urine and feces. Since then the paralysis has advanced upward about 4 inches. She has suffered almost constantly with girdle pains for the last year.

*Physical Examination.*—There is a moderate kyphosis from the 7th to the 10th dorsal vertebra and a marked lumbar lardosis. Spastic paralysis in both lower extremities. Superficial abdominal reflexes absent. Knee-jerks barely present, no clonus or Babinski. All sensation to touch, pain and thermal changes is absent to the level of the 6th dorsal. There is an area of hypersensitiveness just above this. Incontinence of urine and feces.

Roentgen-ray examinations were made on January 11th and February 3rd and 5th. Examination of the roentgenograms of the lower dorsal region shows a definite lesion which is characterized by destruction of the intervertebral disc and erosion of the bodies of the vertebrae. Just below and to the right of the spinous process of the 11th there is a dense shadow in which there is evidence of calcification. Probable diagnosis, tuberculosis, but sarcoma considered (Figs. 1 and 2).

Laminectomy done on February 5th. Pathological report: Chondrosarcoma.

Case II (Hospital No. W.S. 211282.) C. C. Female. Age, fifty-five. Admitted October 24, 1916.

*Present Illness.*—About fourteen months ago, while gardening, patient suddenly experienced extreme pain in her left leg. Eleven months later, the right leg became similarly affected. Treatment previous to entrance had been morphine for the relief of the intense pain which is persistent.

*Physical Examination.*—The patient appears to be in great pain, the history being obtained

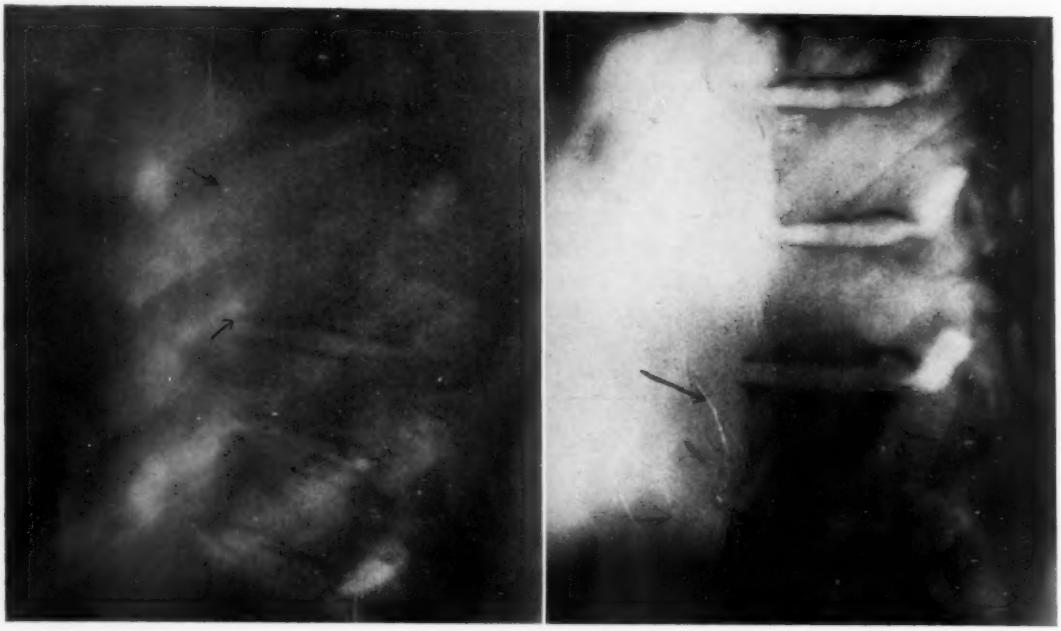


FIG. 1. FIG. 2.

FIG. 1. Case 1. Lateral view of the lower dorsal spine. Note the similarity to tuberculosis of the spine, but erosion of the anterior surfaces of the two bodies designated by the arrows suggests the true nature of the lesion. (From the Massachusetts Homeopathic Hospital Records.)

FIG. 2. Case 1. Note the extensive destruction on the anterior margins of the designated vertebrae, with only slight narrowing of the intervertebral space.

between groans. The legs and hips are complained of most severely. Knee-jerks active and equal. No Babinski. Doubtful clonus on the left. No discoverable change to touch, differentiation between sharp and dull, and temperature stimuli, except on the lower leg where all seem somewhat diminished, but without definite limitation. Tenderness over the third and fourth lumbar vertebrae.

Roentgen examinations were made on October 25th and 26th, and November 2nd and 7th. The plates reveal a distinct deformity of the 5th lumbar vertebra, destruction on the left side with thickening about the joint surfaces, and some irregularity in outline. The fourth lumbar also shows evidence of involvement.

On November 9th a sensory examination revealed a definite clonus, well sustained on the left. Suggestion of Babinski on the right. Muscles of both legs show general weakness. A firm mass was struck in the region of the fourth lumbar when a spinal puncture was attempted.

Laminectomy revealed a roughening of the bodies of the 3rd, 4th and 5th lumbar vertebrae and apparent erosion. Pathological report: Small round cell sarcoma.

CASE III (Hospital No. W.S. 188959.) C. J. DeF. Male. Age, forty-three. Admitted May 5, 1913.

*Present Illness.*—About one year ago patient's back felt as though he had strained it. His local doctor diagnosed the condition lumbago and strapped his back. A few months later he developed pain in the left leg which became worse on exertion and caused him to limp. About four weeks ago the left leg became numb and pained him to such a degree that he could not use it and remained in bed. For the past two weeks, rest in bed has failed to relieve the pain.

*Physical Examination.*—Slight atrophy and some weakness of the left leg. Back is very stiff with a low lumbar scoliosis. Motion and pressure painful. No knee-jerk on left, though present on the right. Romberg backward.

The roentgen-ray examination was negative except for "slight hypertrophic changes."

Laminectomy revealed a new growth in-

volving the second and third lumbar vertebrae. Pathological report: Fibrosarcoma with giant cells.

CASE IV (Hospital No. Orth. W. S. 183172.) A. J. McI. Male. Age, sixteen. Admitted June 26th, 1912.

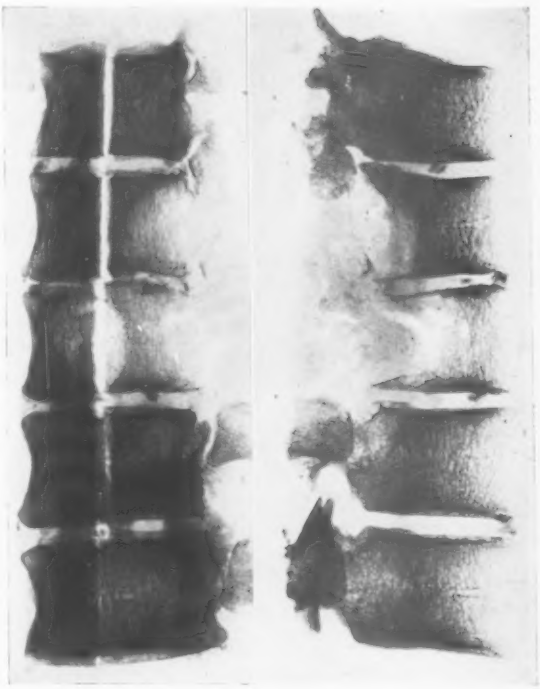
*Family History.*—Mother died of phthisis.

*Present Illness.*—On March 14th, patient fell, injuring the lower dorsal and upper lumbar spine. Was not unconscious, rode home. Since then the pain over this area has gradually increased. Since May 16th has been treated (strapping) in the Out-Patient Department without relief. During the past two weeks a large area over the external and anterior surface of the right thigh has become anesthetic. His gait has changed. Has frequent headaches.

*Physical Examination.*—Walks with some instability, complaining of weakness in the right knee. There is a slight depression over the 10th dorsal vertebra. In the posterior subcostal region on the right, there is an area of swelling the size of the hand, which is very tender on pressure. Straight leg raising to about one third, beyond that pain in the region of the 4th lumbar to the right of the spine. Clonus and Oppenheim present. Area of analgesia present over the external aspect of the right thigh just below the trochanter.

Operation revealed a tumor which consisted of encapsulated liquid containing broken-down tissue which was reported by the pathologist to be "giant-cell sarcoma."

The roentgen-ray examination was post-operative, and showed continued evidence of the disease.



FIGS. 3 and 4. Roentgenograms from a specimen from the Warren Museum, Harvard Medical School. "A portion of the dorsal region showing a new growth which had started in the body of one of the vertebrae and appeared on the outside along the spinous process." (From the records of the Museum.) Although three bodies are involved, no one is completely destroyed. Intervertebral spaces are only slightly lessened and the process seems to have attacked the posterior portions of the bodies.

## CONCLUSIONS

Primary sarcoma of the vertebae is not a common lesion. It may or may not give roentgenographic evidence of its presence, and when it does the findings are easily confused with Pott's disease. Repeated examinations showing the rapid destruction of bone, with but little involvement of the intervertebral discs, are necessary to determine the true character of the lesion. With the advent of the Potter-Bucky diaphragm, spinal pathology being much better observed, the determination of lesions therein may be more accurately made.

In conclusion, I wish to thank Dr. George W. Holmes, whose kind assistance has made this paper possible.

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# MY STUDIES ON THE PHYSICIAL FOUNDATIONS OF DEEP THERAPY TREATMENT*

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## PART I

### STUDY OF THE PHYSICAL CONDITIONS

MR. PRESIDENT, Members of THE AMERICAN ROENTGEN RAY SOCIETY, Ladies and Gentlemen: Your President invited me to make a report on my work in deep therapy, and I have undertaken with pleasure the long trip to make the report and to learn a great many new things in your beautiful country; for in the exchange of knowledge lies the progress of science. There should be no barrier to things which are of benefit to all humanity.

I wish to present in two short papers the results of my studies. The first paper deals with the physical laws of irradiation and the exact knowledge of the distribution of the rays within the tissues. The biologist can only draw conclusions from the reaction on tissue when the above-mentioned conditions are accurately ascertained.

The second line of study, which was far more difficult than the first, covers the technical requirements for a practical solution of the problem. This problem has in part been solved in your country. I have been working in Germany on the development of the apparatus and have spent many years of thought on producing one that would generate very high voltages and would operate continuously without change under conditions of absolute safety and within small dimensions; that is, an apparatus which could be used by the medical man without danger and without great expense for operation and upkeep. In the meantime my friend and co-worker, Dr. W. D. Coolidge, has still further developed his wonderful tube, with which I could obtain the most accurate results and with which I could bring to their best effect the high voltages. This subject will be covered in my second paper.

Before arriving at my last results, I shall briefly touch upon the history of how the problem started. In 1904, nearly seventeen years ago, I first formulated the problems. At that time superficial skin diseases were being treated with roentgen rays. A few men, among them Americans—Senn, for instance—had made experiments to ascertain whether diseased areas which were not situated at the surface could be influenced by the rays. The results were not satisfactory, and Professor Perthes, a German surgeon who was studying these matters at the same time, published interesting experiments, coming to the conclusion that an insufficient quantity of rays penetrate to a depth. I naturally approached the problem from the physicist's point of view and found at that time the following situation: At the surface a cure by rays could be noted, the physical conditions were therefore right for a good result at the surface. I therefore concluded that it only would be possible to determine whether a disease in deep tissues could be cured, if we could produce in them just as favorable physical conditions of the rays as when they were applied to the surface. I asked myself: What are the physical conditions at the surface, and is it possible to produce these same physical conditions at a depth?

In two simple diagrams I shall show the foundation of the problem. You know that in whichever way roentgen rays are produced—with high tension direct current,

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alternating current, induction coil or transformer, it is never possible to produce *one kind* of rays only, but always a *mixture* of different rays.

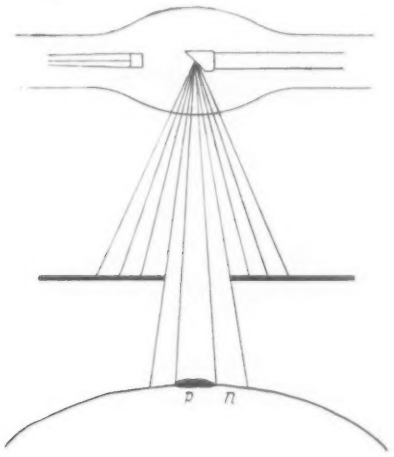


FIG. 1.

In the first picture a lesion is shown on the surface of the body. When it is rayed from a focus placed at a certain distance, just as it was done seventeen years ago, and

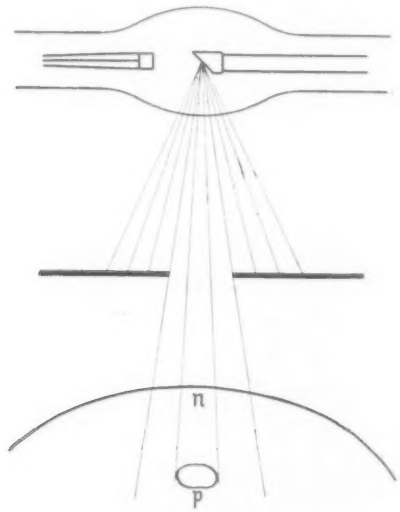


FIG. 2.

the rays strike the skin and the proper dose given, it may happen that the disease is cured without the skin being damaged. The biologist will say the reason is that the cells of the diseased part are more sensitive than those of the healthy part; and if that is the case the physical part is very easy, because healthy and diseased cells when rayed from the same tube receive the same quality and quantity of rays. The physical conditions are the same on all points of the surface, i.e., we have a homogeneous field.

Regarding the second figure, in which the diseased part is a few centimeters below the surface, the physical conditions are very different—*qualitatively* different, because the depth receives a different composition of rays compared with the composition on the surface, owing to the absorption of the long wave-length rays in the beginning of their path; *quantitatively* different, because we have fewer rays at the depth than on the surface on account of the greater distance and the loss by absorption. The physical conditions in the depth are therefore not the same and the biologist cannot compare the reaction on the surface with the effect in the depth. From these considerations I developed the physical laws of deep therapy, which are known in Europe as the *Laws of Homogeneous Irradiation*. They were the foundation for the development of deep therapy, and have to-day proven to be true in all points. To-day it is very simple and natural, but it was not so seventeen years ago, when the nature of roentgen rays was unknown and their laws could not have been known. Amongst those who had grasped at the first the importance of the physical laws of deep therapy and had made use of them consciously I should like to mention Beclère of Paris and Wetterer of Mannheim.

The laws of homogeneous irradiation are in abbreviated form the following:

*First Law.* The foundation of roentgenotherapy is formed by the biological experience that different cell forms show different sensitiveness to the same roentgen rays.

*Second Law.* Rays of different penetration are to be regarded as different medicaments, so long as the contrary is not proven. The difference in sensitiveness of different cells appears more marked if hard rays are applied.

*Third Law.* In order to determine and utilize precise differences in sensibility, the

homogeneity of the field of radiation is a required condition.

*Fourth Law.* The non-homogeneity of a treated field detracts from the effect. The conditions for a favorable influence upon the disease are not fulfilled when the non-homogeneity of the field is greater than the difference in sensitiveness between the diseased cells and the healthy.

This law, the law of the *limit of effect,* can easily be expressed by algebraic formulae.

If we had a quantitatively homogeneous radiation and a diseased cell which is *a* times as sensitive as the normal cell, then a favorable effect can take place when the intensity $I_n$ on the normal cell is not more than *a* times as large as the intensity $I_p$ on the pathological cell given the same time of radiation. In a certain time *t* the reaction is equal to the product of intensity times sensibility. At the moment when the product on the normal cell becomes larger than on the diseased cell we have reached the *limit of effect.* We can formulate:

$$I_p \times a \times t \geqq I_n \times t.$$

*Fifth Law.* There is a homogeneity of space or quantitative homogeneity and a specific homogeneity, or qualitative homogeneity. The aim must be to dose the diseased cells of the entire diseased zone throughout its extent with the needed quantity or dose of irradiation, and to have this dose of the same quality throughout.

*Sixth Law.* The condition of qualitative or specific homogeneity is fulfilled when the irradiation in the complete zone during its course through the body does not change its composition or consistency. The reaction on the different cells is then physically only dependent on the *intensity and the time.*

*Seventh Law.* The intensity of effect may not differ more than the degree of sensitiveness. This is only a more precise statement of the fourth law, the *limit of effect,* but one may try to increase the intensity on the diseased zone in the depth and to raise it above the intensity on the surface, and in the vicinity of diseased cells.

For seventeen years, unceasingly, I have tried to fulfil the above-mentioned conditions in the deeper tissues of the body, and to work out for the medical man some simple method by which he may know the physical effect of irradiation in any part of the body, both qualitatively and quantitatively. It was and is possible to improve the conditions with the old methods—by using penetrating qualities of the radiation, better machines and tubes, by raying from great distances, from different angles, so as to make the rays cross within the body (the cross-fire method), and by the use of exactly determined filters; but perfect results are only obtained when using extremely high voltages and making use of the diffused radiation within the body or in media physically similar to its tissue. My last work, a part of which Dr. Coolidge saw on his visit last year, consists of measurements made during many years and shows the following results:

Having *a well-known composition of rays* (Part II will explain how they were produced) *we have measured the distribution of the intensity of irradiation within a body* (Figs. 3, 4, 5 and 6). These measurements have been made with four kinds of rays—the most penetrating which up to then could have been produced continuously. Five focal distances were studied each for three different-sized treatment fields—small, medium and large. These measurements were undertaken after Friedrich in Freiburg had shown on careful study, that the rays are absorbed in water practically at the same rate as in tissue. It took

Table

The Dose in the Depth in procent of the Dose on the Skin for a rectangular Cone of 50° and 35° opening and 30 cm focal distance.
Total Intensity incl. additional Int. from Diffusion.

| Depth below surface cm | Narrow cone 1/10 reduction of Intensity for a cm Water | Cone of 50° and 35° opening 1/10 reduction of Int. for a gm of W. | Narrow cone 1/10 reduction of Int. for a cm of water | Cone of 50° and 35° opening 1/10 reduction of Int. |
|---|---|---|---|---|
| 0 | 100 | 100 | 100 | 100 |
| 1 | 89·9 | 88 | 88·8 | 90 |
| 2 | 80·6 | 78 | 78·7 | 78 |
| 3 | 71·3 | 68 | 69·1 | 68 |
| 4 | 62·4 | 58 | 60·2 | 57 |
| 5 | 55·4 | 49 | 52·7 | 51 |
| 6 | 48·2 | 42 | 46·2 | 43 |
| 7 | 42·9 | 36 | 40·4 | 36 |
| 8 | 38·2 | 31 | 35·3 | 30 |
| 9 | 34·0 | 26 | 31·0 | 25 |
| 10 | 30·4 | 22 | 27·0 | 21 |
| 11 | 27·1 | 19 | 23·6 | 18 |
| 12 | 24·2 | 16 | 20·7 | 15 |
| 13 | 21·5 | 14 | 18·1 | 13 |
| 14 | 19·2 | 12 | 15·8 | 11 |
| 15 | 17·0 | 10 | 13·8 | 9 |

FIG. 3.

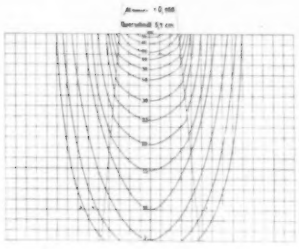

FIG. 4.

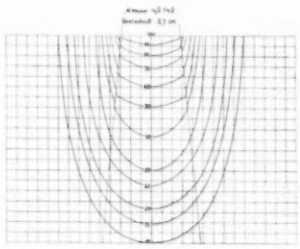

FIG. 5.

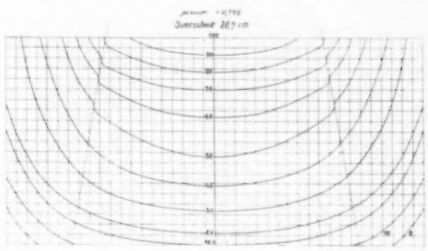

FIG. 6.

FIG. 4. Distribution of intensity with the following factors: Coolidge tube. Voltage about 180,000 volts at transformer; 162,500 volts max. at tube. Filter 0.5 mm. Cu. + 1 mm. Al. Focal skin distance 30 cm. Port of entry 5.7 x 7.6 cm. M in water = 0.166. Transverse section 5.7 cm.

FIG. 5. Distribution of intensity with the following factors: Coolidge tube. Voltage about 220,000 volts at transformer; 200,000 volts max. at tube. Filter 1.3 mm. Cu. + 1 mm. Al. Focal skin distance 30 cm. Port of entry 5.7 x 7.6 cm. M in water = 0.140. Transverse section 5.7 cm.

FIG. 6. Distribution of intensity with the following factors: Coolidge tube. Voltage about 200,000 volts at transformer; 181,500 volts max. at tube. Filter 0.8 mm. Cu. + 1 mm. Al. Focal skin distance 60 cm. Port of entry 20.7 x 27.6 cm. M in water = 0.149. Transverse section 20.7 cm.

us one year to find out an exact method of measuring. Since then we have made thousands of measurements of which I can only give you an idea.

The following figures are an example from the tables published in my Frankfort Institute. If at a distance of 30 centimeters a radiation of a precisely known quality and a treatment field of the size of $5.7 \times 7.6$ centimeters is irradiated, it is possible to find the intensity of radiation at any point in deeper tissues. *In this figure* the localities of equal intensity are connected by lines, which I will call *equal-intensity curves*. If a diseased area is located *here* I can find the intensity of rays it will receive in percentage of the intensity on the surface. The measurements demonstrated many surprises, which were not thought of before, namely, that the intensities in the center of a radiation field are much greater than at the sides in the same depths. The differences amount to 30-60 per cent. It also was not known that the skin in the surroundings of the radiation field receives a heavy dose from the scattered rays. It was thought that this part of the skin was protected by the heavy lead diaphragm at the tube. The consequence of these studies is a *proper method* of a physically correct treatment to be employed in deep therapy. The method actually employed is as follows. First, the physician must make a careful examination and ascertain the location and extent of the growth or lesion, making a sketch of the same, preferably on transparent paper, and in natural size, showing a cross section in the frontal and in the sagittal planes. Hereafter the distribution diagrams are consulted and the quality of the radiation, the focal distance, and the number of treatment fields required for the case are ascertained.

The transparent sketch placed upon the distribution diagram will enable the intensity of the rays to be ascertained in any part of the treated zone. I can only indicate this method, which looks simple at first but is rather difficult to execute. I have the charts with me and will be pleased to show them to anyone who desires further explanation.

Every roentgenotherapist who has made experiments in therapy will have been puzzled about the problem: What is happening in the deeper tissues? This problem is now solved, but there remains the fact that the human body is not simply a regularly formed geometrical object but a complicated structure, and it is impossible to guess in which direction a ray is passing through the body at a certain setting of his appliance, especially by using the old-fashioned tube stands. It is very difficult to judge the biological effects and to compare results, when

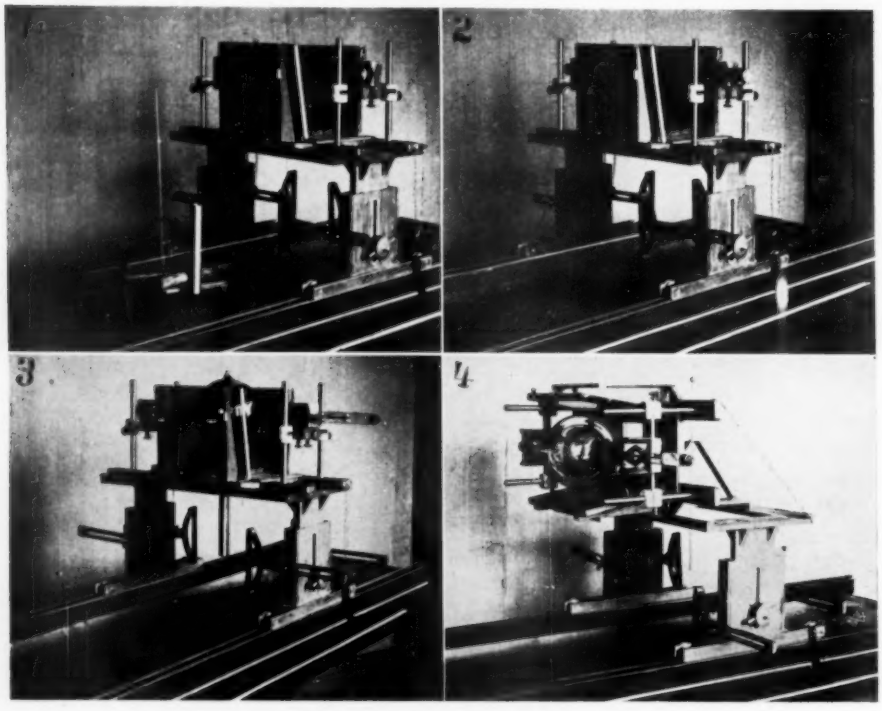


FIG. 7. Treatment appliance.

the same conditions cannot be reproduced. Yet it is possible in many cases to employ artificial means and to change the complicated geometrical form of the body to a simple geometrical form and to use in place of complicated appliances a *simple appliance* (Fig. 7) which has movements only at right angles in a vertical and horizontal direction. I suggest the following method be employed in all cases wherever possible:

1. To make out of the complicated form of the body a form with simple and straight surfaces by using small water-filled rubber bags, a layer of paraffin wax, gelatine, flour paste (dough) or some similar material. When employing such straight forms we find that the distribution of energy within the body tallies very accurately with the physical measurements and tables.

2. To employ an appliance which is set at right angles over the patient and a resetting of which can be reproduced at any time. If we employ these new methods consciously, we will find that some cancer cases cannot yet be successfully cured at all, because the purpose of radiation cannot be accomplished, i.e., to ray every part of the diseased tissue with the same and sufficient intensity. In many other cases we find only one possibility of the treatment and any variation from this would be dangerous. We may neither change the focus distance nor the quality of the radiation, nor the size of the field. The intensity must never be too small nor too large. Whether a case can or cannot be treated successfully should be settled *before* a course of treatment is begun.

The fact that so many different methods of *x*-ray therapy are employed in the various clinics may be explained by the comparatively recent development of a correct deep treatment.

I wish to point out two objections to this method. There is a difference when air is enclosed within tissue, as for instance the lungs. In my Frankfort Institute, where we are fortunate in having the cooperation of the surgical clinic of Prof. Schmieden and Dr. Holfelder and the gynecological clinic of Prof. Seitz and Dr. Gutmann, we are investigating these cases and ascertaining how the distribution in this case can be compared

with that in water. The second objection may be expressed by saying that *the biological conditions are much more complicated.* I accept this objection, but add that in solving a complicated problem we must take each point and clear the same one by one. The biological problems become clear only after the physical conditions are definitely known, and with this method there is a way. For each case it is possible to arrange the physical conditions so that they may be repeated at any time; hence it becomes possible to estimate the biological effect of a definite physical condition. That has been the aim of my studies on the physical foundations of deep therapy.

## PART II

### ELECTRICAL AND TECHNICAL STUDIES

At the beginning of the investigations it was ascertained that the conditions for the "homogeneity of the irradiation" could only be fulfilled by the use of very "hard" rays. The hardness of the rays depends upon the voltage on the tube. All recent investigations have proven this fact, and therefore it was necessary to realize these requirements by solving *two* technical problems:

1. The invention and development of roentgen-ray tubes which would stand very high voltages continuously.

2. The invention and development of electrical apparatus which would generate safely very high voltages with great reliability and safety from breakdown.

The solution of the first problem was given in the main part by the inventions of Dr. Coolidge and his co-workers, which are sufficiently well known to all and the results of which I admire greatly.

The other problem, to produce electrical apparatus delivering high voltages continuously and safely, appeared to be easy, but eventually was very difficult. An ordinary induction coil of the old type, for instance, one of a 40 cm. spark, would deliver the necessary voltage but would unfailingly break down if it was used continuously. It was natural that this should happen, according to the laws of the dielectrical strength of insulating materials, because this material as was used was overstrained. Besides, the conditions became uncontrollable through the use of an interrupter which introduced inconstancy of the discharge and rays generated.

It is not difficult to build a transformer for 250,000 volts alternating current and more, and it has often been accomplished, but to build this transformer properly and to make it stand up under continuous use, it has to be *of very large dimensions* and expensive. Its weight would be very great and it would hardly find room in a physician's office.

This is the logical consequence of the high

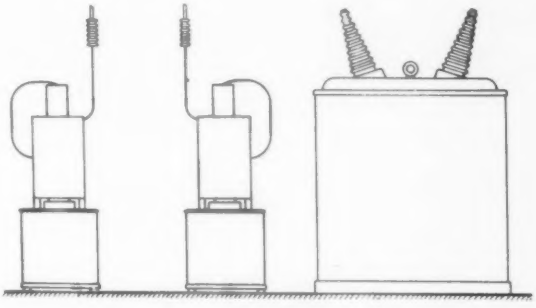

FIG. 8.

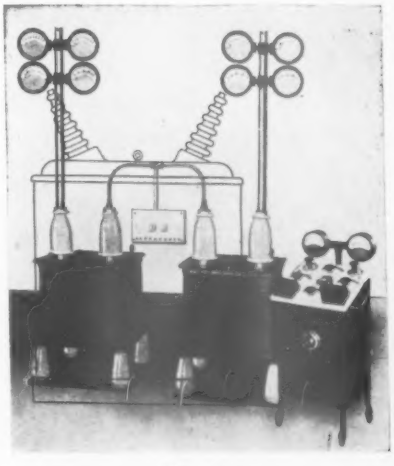

FIG. 9.

voltage which *fixes the dimensions for the insulating materials*, because each material has only got a certain definite electrical stability, which is well known to electrical engineers. Many transformers were built with insufficient insulation. They would work a short time but would eventually break down. Such failures have happened in Germany by the hundreds during treatment work. Imagine further, that even such transformers which are properly dimensioned, for instance,

2. To construct the transformer in such a manner that *by adding new parts* the voltage could always be raised another step, say, to *three hundred thousand* volts and more when such tubes are available. For it is without doubt, and all experiments have proven the fact, that *the conditions for deep therapy are continuously improved with higher voltages*. It may take some years before this voltage is applicable, but it will mean shorter doses and a *greater protection of the skin*

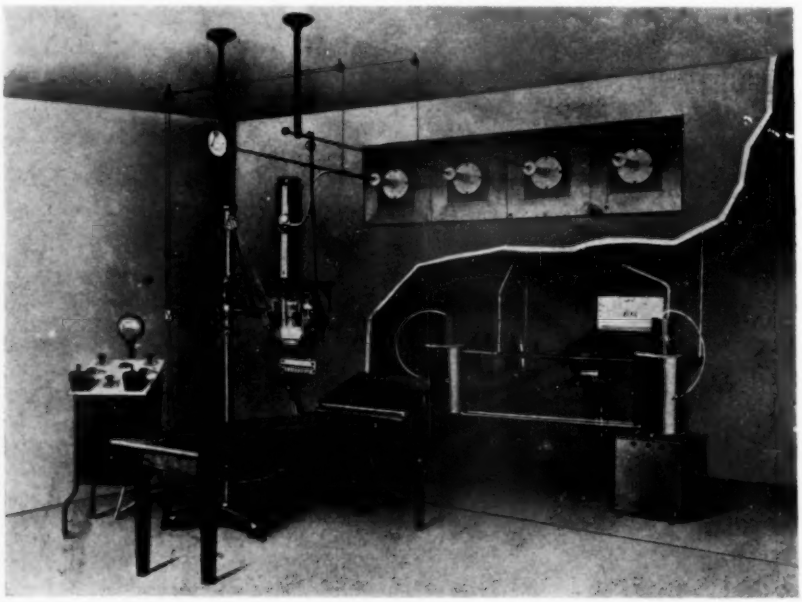

FIG. 10. Apparatus with open iron core transformer.

for 250,000 volts continuous service, will lose *their value* as soon as tubes will be constructed that will stand 350,000 *volts and more*. Every ordinarily constructed transformer will lose its value when higher voltages are required.

*The most interesting* of all the electrical studies of my co-workers and myself, and the most laborious, was the development of voltage generators for 250,000 to 500,000 volts and more, and I have spent many years in developing the transformer that would fulfill the following conditions:

1. To be compact, light and inexpensive and yet be able to produce high voltages with absolute safety and without danger to the insulating material when operating ten hours daily throughout the year.

*during treatment*. It would be very painful for the medical man to have to discard his old transformers every time an advance is made in the maximum voltage applied on the tube.

I solved this problem in 1915 and built up a transformer in 1916 for 500,000 volts, which *voltage I could have raised indefinitely*. The transformer, for instance, is constructed of units, each for 100,000 volts, and I made a careful study of all conditions involved, some of the results of which I wish to show you.

The figures show a comparison of an ordinary 200,000 volt transformer compared with one built for the same voltage under the new principles. This new type has been built since 1916, for therapeutic

purposes, and many hundreds are in daily use, eight to ten hours a day. A puncture from secondary to primary is unknown, whereas there have been very sad experiences with the usual type of transformers which had to be frequently repaired. The new transformers can be built with an open iron core or a closed core equally well, and the transformer is also being built and used for ordinary technical requirements, for testing purposes and precipitation work, they being less than half as expensive, with better conditions of the insulation than the normal type. Many modifications in the construction are possible, but it is rather difficult for the layman to grasp the principle. I will briefly explain the principle, but cannot go into details, as for instance, when to use a single or multiple iron core.

The principle is simply the following: To construct the transformer in such a manner that the coils carrying the highest voltage towards the earth and the primary winding do not have to withstand the full voltage, but that the highest voltage *is carried by and removed to a point where it can do no harm.* This sounds paradoxical, but I shall try to explain it.

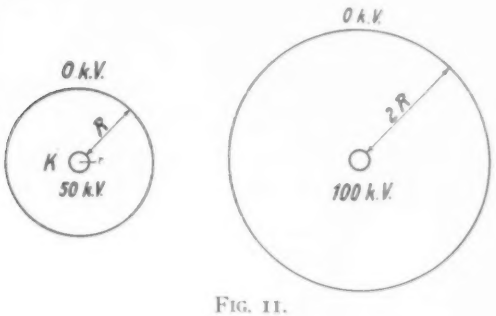


FIG. 11.

In Figure 11, K is a sphere-shaped conductor of a radius *r*, the sphere is at a potential of 50,000 volts in relation to a sphere surrounding it. According to what material is used for insulation to prevent a puncture, the radius R of the outer sphere is fixed. The volume of insulating material required corresponds to the volume of the outer sphere minus the inner sphere, or if the radius of the inner sphere is very small the quantity of insulating material required is $V_1 = 4/3\ R^3 \pi$. If the potential between the inner and outer sphere is raised to 100,000 volts, the space R must be made larger. As the insulating quality of material is reduced with the higher voltage, a larger layer, for instance, of double the thickness of oil, will not be sufficient for the double voltage. But for the sake of simplicity we will assume that it is suffiicient. The volume of insulating material is then formulated thus: $V_2 = 4/3\ 2^3\ R^3 \pi$, i.e., eight times as large. The insulating material required for a double voltage is therefore *eight times greater.*

The idea of my invention was the following:

If we divide up the high tension we can reduce the requirements of insulating material from a geometrical progression into

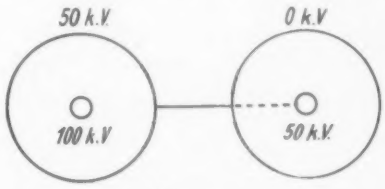


FIG. 12.

an arithmetical progression, as is illustrated in Figure 12. The total voltage, which has to be insulated, is divided up into two systems in series, and in this case only one quarter of the insulating material is required for the above mentioned 100,000 volts.

I shall try to make the idea clearer by using as an example a 100,000 volt roentgen-ray transformer with one terminal grounded, the primary being fed from *the mains.*

In Figure 13, $W_1$ is the primary winding, $W_2$ the secondary winding of a high tension transformer. The high tension terminal *a* is grounded. This is an assumption but no essential requirement for this system, and only introduced to make the matter more understandable, the potential being fixed in this case. The low voltage end is fed from the mains and has practically the same potential as *a*, the 100 or 200 volts of the mains playing no part. We now have the peculiar condition that the insulating tube between the primary and secondary

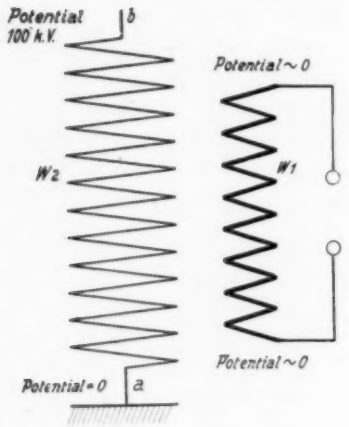


FIG. 13.

winding is carrying all voltages from zero to 100,000 volts along its length and that the lower end at *a* has no voltage whatsoever, but the upper end *b* the maximum voltage of 100,000 volts. At *a* the insulation is wasted and at *b* it has to be considerably intensified to prevent corona and puncture.

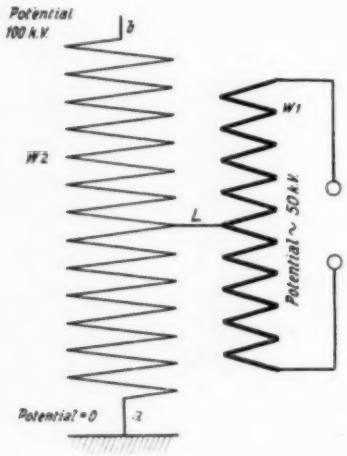


FIG. 14.

It is possible to eliminate the uneven strain on such a transformer and to reduce the insulation material by a device which solves the serious question of insulation in principle. The reason for the high insulating stresses on the corona of our example, is the fact that the secondary winding surrounds along its whole length a primary practically at earth potential, it being connected to the mains. If it were brought up to a potential of half the total voltage, the tension between the high tension pole *b* and the primary could be reduced to half. Figure 14 shows you how this can readily be done, by connecting the middle of the high tension winding with the primary by means of a charging conductor L. The potential of the *primary* is then controlled and constantly held at 50,000 volts; the charging current is exceedingly small, and all insulating material is immediately carrying only half the strain. The question arises, how to get the energy into the primary without changing its potential of 50,000 volts? This could be done by connecting the primary to an insulated generator, but practically it is simpler to feed *through a current transformer* with a ratio of one to one, for instance, but with an insulation of 50,000 volts between windings.

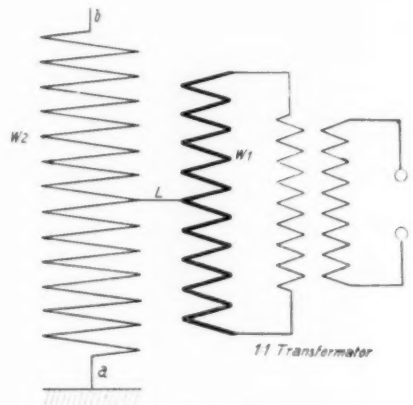


FIG. 15.

This is illustrated in Figure 15. This transformer does not function as a "step-up" transformer, but merely takes away part of the insulating work from the "step-up" transformer, by *changing the insulating factor from a geometrical to an arithmetical progression.*

The above explanation is only an example; the whole thing can be done on a single iron core. But what I wish to illustrate is the fact that this method differs from that of employing two or more transformers in series or parallel.

The principle of the new transformer consists in the following:

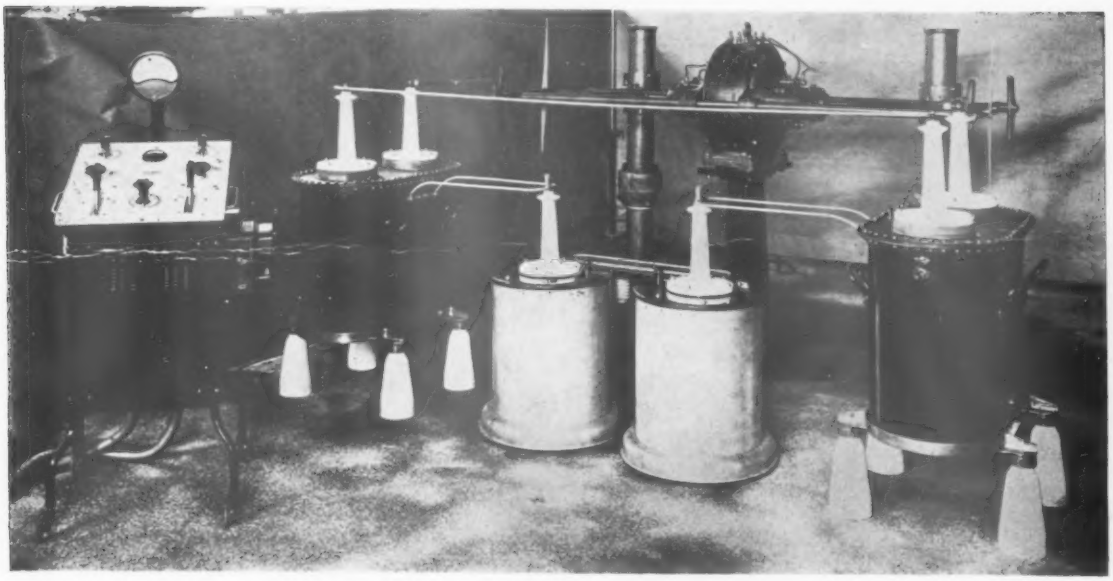

Fig. 16. Apparatus with current transformer and closed core.

Fig. 17. Apparatus with closed core and current transformer on the same iron core.

*First.* The separation of the problem of "transformation" from that of "insulation" in the construction of a transformer.

*Second.* Intentional holding of the energizing winding of a transformer at a different potential from earth than the feeding mains.

*Third.* Holding the energizing winding at such a potential that the insulating strain from the secondary winding to the primary is *reduced far below the danger zone.*

*Fourth.* The subdivision of the secondary coil.

What I have tried to explain is only an example; but by the introduction of these principles into the building of transformers, it was possible to introduce such constancy in the work of various clinics that the conditions could be reproduced over and over again. When using the 200,000 volt Coolidge tube, it was possible to work with definitely determined tension and corresponding rays; the feeding alternating current being entirely of the same sine curve. The biological results of the different clinics can now be compared and repeated.

Some of the completed transformer installations built under these principles are shown in Figures 10, 16, and 17.

We have been constructing the type of apparatus with open iron core (Fig. 10) in Germany because of the generally entertained fear of danger to life from high electrical discharges from closed core transformers. The apparatus with current transformer and closed core (Fig. 16) and the apparatus with closed core and current transformer on the same iron core (Fig. 17) are more efficient. The difficulty of producing high voltages is overcome, the transformer can be made smaller and at a lesser cost than heretofore. There is still the necessity of applying this voltage through a rotary or kenetron distributer or rectifier to the tube. We have succeeded in the research laboratory in operating Coolidge tubes at 200,000 volts without rectifier on alternating current, but there are a number of drawbacks. When it becomes possible to send still larger currents through a tube it will be possible to cut down the time of treatment by applying any doses wanted at any part of the body according to the laws of homogeneous irradiation without burning the skin or other sensitive parts.

I do not want to leave the impression that now all cancer growths can be cured. I am a physicist and limit myself to investigating the principal problems by scientific means. I am convinced, and you will agree with me, if I say that wherever nature may show us physical or chemical means by which a chance is given us to help the sick, we must make an exact study of its possibilities. And the opportunity to help will be lost if we do not study the conditions shown us by nature; but it becomes a good chance if we get at a physical method well studied and not left to chance. When to make use of such methods and to what extent I do not know; nature will show this to the medical man. I know that my part of the work was and will remain to sharpen the weapons with which the medical man can fight disease.

# THE EFFECTS OF SCATTERED X-RAYS IN RADIOGRAPHY*

By R. B. WILSEY

Communication No. 125 from the Research Laboratory of the Eastman Kodak Company

ROCHESTER, NEW YORK

IN a recent paper on the "Intensity of Scattered X-Rays in Radiography,"[1] the author presented data showing the relatively high intensities of scattered radiation reaching the film under conditions similar to those in the radiography of deep parts. For instance in radiographing through 4 inches of water, it was found that 71 per cent of the radiation affecting the film was scattered radiation; for 6 inches of water this proportion was 83 per cent, and for 8 inches of water, 88 per cent. These values were for a 5 inch spark gap, 20 inch target-film distance, and with no cone or diaphragm limiting the rays other than the circular opening in the lead glass shield surrounding the radiator type Coolidge tube. It is evident that such large intensities of scattered radiation should produce a considerable effect upon the quality of the radiograph. Except in some simple cases it would be difficult to estimate quantitatively what would be the effects of any given intensity of scattered radiation upon the radiographic quality. It was the purpose of the present experiments to obtain some measurements of the effects of scattered radiation under typical conditions, and to compare the effects of reducing scattered radiation with the results obtained by other methods of improving the quality of radiographs of deep parts, such as the use of intensifying screens and reducing the spark gap.

The two physical characteristics of the radiographic image which govern its diagnostic value are its contrast and its definition.† Any sign or detail in a radiograph is distinguishable by reason of its contrast with surrounding areas, just as any object in nature is visible by reason of its contrast in color or brightness with its background. Within certain limits, the greater the contrast of an object with its background, the greater is its visibility. The apparent contrast is also greater when the dividing line between object and background is sharp than when the outline is diffuse, hence the importance of good definition. The better the definition the more information is obtainable about the finer structural details. Contrast in the finer details and definition are closely related; however, it is not the purpose here to analyze the connection between contrast and definition but rather to use the measurement of these factors in comparing the values of various methods in radiographic technique.

The relation of intensifying screens to the problem of scattered radiation is also of special interest; the improvement in contrast produced by intensifying screens in the radiography of deep parts has given rise to the belief that intensifying screens reduce the effects of the scattered rays. Experiments were therefore performed to study the reaction of intensifying screens to scattered rays and to determine how the action of intensifying screens compares with the effects of an actual reduction in intensity of the scattered radiation.

In the experiments upon contrast, a set of artificial conditions were chosen as being fairly typical of those occurring in the radiography of deep parts. The experimental arrangement is illustrated in the diagram shown in Fig. 1. The scattering material was a depth of 6 inches of water contained in a tank 12 inches square; the bottom of the tank was of aluminum 1/32 inch thick. Immersed in this was a block of beef bone 3/8 inch thick and about 1/2 inch square. The tank rested on a lead sheet 1/16 inch thick, in which was a circular hole 3 inches in diameter. The film in a cassette or exposure

†The influence of the preparation and positioning of the patient upon the diagnostic value of the radiograph is a medical question and is outside the scope of the present investigation.

*Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 28, 29, 1921.

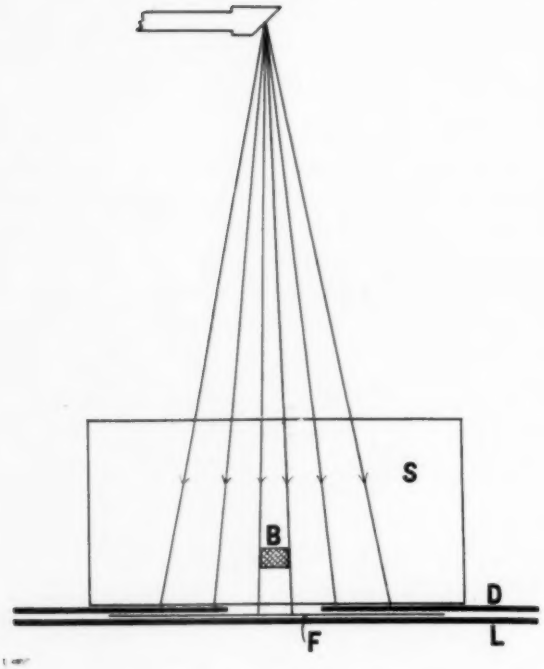


FIG. 1. Diagram of experimental arrangement in experiments on contrast. S, scattering material; B, small block of beef bone; D, lead diaphragm with 3 inch aperture; F, photographic film; L, sheet of lead.

holder was supported directly beneath the lead sheet and could be placed so as to receive the exposure through the 3 inch aperture on any portion of the film; by this means six exposures could be obtained on one 8 x 10 film. The block of beef bone placed in the center of the tank was in the path of the central ray and its shadow fell on the film in the center of the circular aperture in the lead sheet.

The first experiment was carried out to determine the effect of "undercutting" of scattered radiation. When an object embedded in scattering material is close to the film, it absorbs the diffuse rays as well as the focal rays, thereby keeping the ratio of their intensities about the same. If the object is some distance away from the film, scattered rays may pass underneath the object with their intensity unaffected by its presence, while the focal rays are absorbed as much as before. This effect is illustrated in Figure 2. The result is that in the shadow of this object the ratio of diffuse to focal radiation has been increased, as is shown by the following experiment. The block of beef bone, immersed in 6 inches of water, was radiographed at various distances from the bottom of the aluminum tank, the exposures being made upon adjacent portions of one sheet of film. Four such films were made, the exposure conditions being the same throughout: 5 inch spark gap, 3.8 ma., 20 inch target-film distance, and exposure time twenty seconds; the films were given the standard development of five minutes in a tank of Elon-hydroquinone developer at 65° F. The density difference between the shadow of the beef bone and the surrounding area was measured. The mean values from the four films are recorded in Table I. The loss of contrast is quite marked as the section of bone is moved away from the

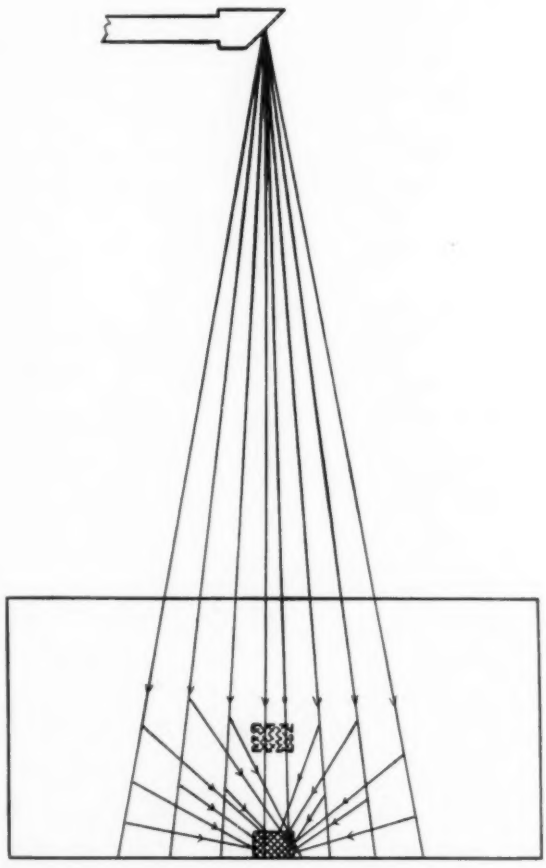

FIG. 2. Diagram illustrating "undercutting" of scattered radiations.

TABLE I

| *Distance of beef bone from bottom of scattering material* | *Density of bone shadow* $D_b$ | *Density due to exposure through water alone* $D_w$ | *Density Difference* $D_w - D_b$ | *Relative Density Difference* |
|---|---|---|---|---|
| 0 inch | 1.05 | 1.47 | .42 | 1.00 |
| 1 inch | 1.26 | 1.43 | .17 | .40 |
| 2 inches | 1.36 | 1.51 | .15 | .36 |
| 3 inches | 1.38 | 1.50 | .12 | .28 |
| 4 inches | 1.39 | 1.52 | .13 | .31 |
| 5 inches | 1.40 | 1.53 | .13 | .31 |

film, most of the decrease occurring within a distance of two inches; for all greater distances, the contrast is practically constant, and has about one-third the value obtained when the beef-bone is close to the film. If there were no scattered radiation the contrast in the radiograph would be independent of the position of the beef bone in the water.

The effects upon contrast of various types of technique were investigated in a somewhat similar manner. Under a given set of conditions the section of beef bone immersed in water was radiographed, a series of exposures being made on successive areas of an 8 x 10 film. The densities of the shadows of the beef bone and of the surrounding areas were measured and the corresponding differences in density between the bone shadow and the surounding area were plotted against the density of the surrounding area; this density difference is a measure of the contrast obtained in the given experiment. Figure 3 shows some curves obtained in this way. The density of film in the shadow of the section of bone is designated by $D_b$, while the density of the surrounding area, produced by radiographing through water alone, is indicated by $D_w$. The difference, $D_w - D_b$, is plotted against $D_w$. In this case, the section of bone was 2 inches from the bottom of the aluminum tank which contained water to a depth of 6 inches. The tube was run at a 5 inch spark gap with a current of 3.4 ma. and a target film distance of 20 inches; the films were given the usual standard development. Each curve is the result of two such films. Curve 1 was made with only the lead glass shield limiting the rays (image diameter 20 inches); curve 2 shows the effect of diaphragming the image size to 4 inches, and curve 3 the effect of decreasing it to 1¾ inches. Figure 4 shows the effect of double intensifying screens upon the contrast, the exposures being made with a tube current of 10 ma., otherwise the exposure conditions were the same as in the previous experiment. Curve 1 represents the results without

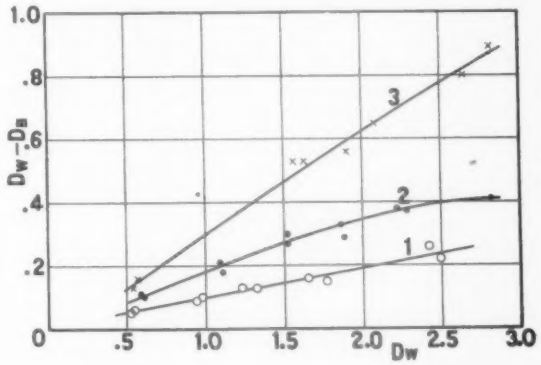


FIG. 3. Curves showing improvement of contrast produced by circular diaphragms over the scattering material. Each abscissa value is the density of film exposed through the water, and the corresponding ordinate is the contrast between that density and the density in the shadow of the beef bone. Curve 1 is for an image diameter of 20 inches; Curve 2, image diameter 4 inches; and Curve 3, image diameter 1¾ inches.

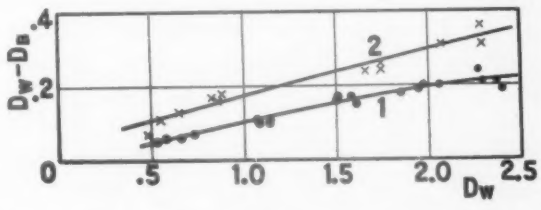


FIG. 4. Curves showing the effect of double intensifying screens upon the contrast; Curve 1, plain duplitized film, and Curve 2, duplitized film between double screens.

screens and curve 2 the values obtained with the double screens. The average density difference ($D_w$–$D_b$) obtained with intensifying screens in this case is 60 per cent greater than that obtained with the film alone.

The effect of diaphragms in improving the contrast is not always as great as is indicated by the curves of Figure 3; the effect was found to vary with the distance of the beef bone from the film. The improvements in contrast produced by various sizes of cones or diaphragms, by double intensifying screens, and by reducing the spark gap from 5 inches to 3 inches, with the beef bone at various distances from the film, are shown in Table II. A thickness of 6 inches of water was the scattering material. The diameter of the image as limited by the cone or diaphragm, with the target-film distance kept at 20 inches, is given as a measure of the degree of diaphragming of the rays.

TABLE II

| *Exp. No.* | *Spark Gap in inches* | *Tube Current (ma.)* | *Image Diameter in inches* | *Intensifying Screens* | *Relative Density Differences Beef Bone in bottom of 6" water* | *Beef Bone from bottom 1"* | *2"* |
|---|---|---|---|---|---|---|---|
| 1 | 5 | 4 | 20.0 | none | 1.00 | 1.00 | 1.00 |
| 2 | 5 | 4 | 4.0 | none | 1.15 | 1.96 | 1.80 |
| 3 | 5 | 4 | 1.75 | none | 1.35 | 3.07 | 3.11 |
| 4 | 3 | 7 | 20.0 | none | 1.46 | 1.53 | 1.55 |
| 5 | 5 | 10 | 20.0 | double | 1.54 | 1.76 | 1.61 |

The average density differences were obtained from curves like those shown in Figures 3 and 4; that obtained upon plain duplitized film with a 5 inch spark gap and image diameter of 20 inches was taken as unity in each case so that the figures given in this table represent the magnification of the contrast produced by variations from this technique.

The effect of double screens upon the contrast is seen to be about the same for each position of the beef bone; (Exp. No. 5) the variations in the observed values cannot be taken as indicating definite differences in contrast. The same can be said of the effect of reducing the spark gap to 3 inches (Exp. No. 4). The improvement in contrast produced by diaphragming down (Exp. Nos. 1-3) is greatest when the section of bone is some distance from the film and is greater in this case than the effect obtained with intensifying screens. When the beef bone is close to the film, diaphragming has much less effect on the contrast, the effect obtained in these experiments being less than that obtained with intensifying screens or by reducing the spark gap; even in this case if more of the scattered rays were removed, the contrast would probably exceed that obtained by the other methods. The values obtained in these contrast experiments would have been somewhat different if an object of different absorption had been used instead of the section of beef bone; however, the character of the results illustrates quite clearly the action of the scattered rays, and shows the degree of improvement possible when their intensity is reduced.

Scattered radiation reduces the contrast in all parts of the radiograph; its greatest effect is upon portions of the subject at some distance from the film so that portions near the film show up most clearly and the portions away from the film show less clearly or not at all. The effect of reducing scattered radiation is to improve most the contrast in portions of the subject away from the film, so that all portions of the subject show up in the radiograph more nearly according to their true absorption for *x*-rays. Greater contrast can be secured by a reduction of the scattered radiation than by the use of intensifying screens or by reducing the spark gap; this advantage is greatest for portions of the subject at a distance from the film.

An experiment was performed to determine the effect upon contrast of using a filter between the scattering material and the film. The beef bone was immersed in a depth

of 6 inches of water at a distance of 1 inch from the bottom of the tank. Four films with six different exposures on each were made without the filter and four similar films were made with a filter of .001 inch of lead foil between the scattering material and the film. All the films were developed alike. The average density difference obtained with and without the filter agreed within one per cent. Such good agreement is accidental, but it shows that a filter used in this way is of no appreciable benefit and its only effect is to increase the exposure. In the previous investigation it had been found that this thickness of lead foil reduced the proportion of diffuse radiation from 83 per cent to 79 per cent. Owing to the absorption of softer rays in the lead foil the image is produced by harder rays which give less contrast and counteract the improvement to be expected from the lower relative intensity of scattered radiation.

Scattered radiation is not reduced by giving a light exposure. Under any set of conditions, the scattered radiation reaching an area of the film is a certain definite proportion of the total radiation on that area and whenever any radiation at all is recorded by the photographic surface, the scattered rays produce their definite proportional effect. The curves which have been exhibited (Figs. 3 and 4) show that the contrast ($D_w - D_b$) increases with exposure; underexposure simply adds its effect to the scattered radiation in reducing contrast.

The values of various techniques in showing up very faint differences in absorption were compared by radiographing a disk of celluloid 1/10 inch thick immersed in a depth of 6 inches of water at a distance of 2 inches from the bottom. A radiograph made with a 5 inch spark gap, 20 inch target-film distance, and a 20 inch image diameter failed to show the disk; it was not shown by the use of double intensifying screens, nor by reducing the spark gap to 3 inches. However, it could be detected when the image size was diaphragmed to 1¾ inches and was easily visible when the image diameter was reduced to ¾ inch (at 5 inch spark gap with plain duplitized film).

A celluloid disk of double the thickness (1/5 inch) immersed in 6 inches of water at a distance of 2 inches from the bottom was also radiographed by these various techniques. The shadow of the disk could not be detected with any certainty in the radiograph made in the ordinary way with the 20 inch image diameter. An extremely faint shadow was produced with double intensifying screens; the shadow made with the 3 inch spark gap was also scarcely perceptible. By diaphragming the image to 4 inches in diameter, the shadow obtained was quite definite, and further improvement was obtained by diaphragming the image to diameters of 1¾ inches and ¾ inch.

These experiments upon detecting faint difference in *x*-ray absorption are very critical tests of the value of any type of technique. Usually it is much easier to increase contrasts in details that are already visible in a photograph than to bring out details that previously could not be detected. Reducing the intensity of scattered radiation, in addition to improving the general appearance of the radiograph, brings out definitely faint differences in absorption that cannot be shown by other means at our disposal and therefore enables new information to be obtained which was not available by other methods.

The double intensifying screen is not so suitable for detecting faint differences in density when the finest definition is involved. In radiographing a thin layer of cardboard, with no scattering material present, the intensifying screens did not show up the cardboard as well as the film alone, owing to the fact that the film showed clearly the sharp outlines of the cardboard whereas the screens did not; the apparent contrast between two adjacent areas is greater when the dividing line is sharp. But intensifying screens are intended only for the radiography of thick parts, where the definition obtainable as a rule can be recorded satisfactorily by good intensifying screens. Under such conditions the superior contrast produced by double screens gives

them a slight advantage in detecting faint differences in absorption. However, better results are obtained when the scattered radiation is sufficiently reduced. When scattered radiation can be eliminated to a considerable extent, single screens will be better able to take advantage of the improved definition and will probably give all the contrast necessary.

The data in Table II show that the action of intensifying screens is not exactly equivalent to a reduction in intensity of the scattered rays; intensifying screens appear to give the same magnification of the contrast, regardless of the distance of the object from the film, whereas the removal of scattered radiation has a very different effect accordingly as the object is near the film or away from it. To determine how much less intensifying screens record the relative intensity of the scattered rays than does duplitized film, measurements were made by the method described in the former paper[1]. A small lead disk was supported at the surface of the water. In the shadow of this disk only diffuse rays could affect the film, and outside its shadow the total of diffuse and focal radiation fell on the film. The relative intensities of diffuse and total radiation recorded by the combination of film with intensifying screens was measured by the method previously described, the relative intensities being determined by the exposures required to produce equal densities on the film. When films alone were used, the exposure was varied by varying the time with *x*-ray intenstiy constant, on the assumption that a change in the exposure time is equivalent in its photographic effect to the same proportional change in intensity. This assumption holds true for plain duplitized film under ordinary radiographic conditions, but it does not hold for intensifying screens. When screens are used, a given increase in *x*-ray intensity produces a greater photographic effect than the same proportional increase in the exposure time. The time and intensity required to produce a given photographic density are not inversely proportional to each other. Consequently serious errors would occur if in the case of intensifying screens the time alone were varied and the intensities assumed inversely proportional to the times required to give equal photographic densities. Therefore in these experiments with intensifying screens, the exposure time was kept constant and the *x*-ray intensity alone was varied by control of the tube current. The voltage on the tube, as determined by the sphere gap for each current, was kept constant. The relative intensities of diffuse and total radiation were taken as inversely proportional to the tube current required to produce equal densities with the two radiations, all other conditions remaining constant. The radiator type Coolidge tube was run at 60 kilovolts with target-film distance of 20 inches. A 6 inch depth of water enclosed in a 12 x 12 inch aluminum tank was the scattering material.

The data obtained on three types of intensifying screens, A, B, and C, are given in Table III; each value is the mean obtained from ten to twelve films with six exposures on each film. The screens were used in an aluminum cassette. The results obtained with them are compared with the values for plain duplitized film loaded in the same cassette. The value for film loaded in cardboard holders is also given. The aluminum top of the cassette acts as a filter and itself reduces slightly the ratio of diffuse to total radiation.

TABLE III

| *Type of Intensifying Screen* | *Ratio Diffuse to Total Radiation* | *Ratio Diffuse to Focal Radiation* |
|---|---|---|
| Duplitized Film, no screens, in cardboard holder | .83 | 4.9 |
| Duplitized Film, no screens, in aluminum cassette | .81 | 4.3 |
| A Single Screen | .80 | 4.0 |
| A Double Screen | .78 | 3.5 |
| B Single Screen | .79 | 3.8 |
| B Double Screen | .77 | 3.3 |
| C Single Screen | .80 | 4.0 |
| C Double Screen | .77 | 3.3 |

These values are independent of any con-

trast effects produced by the screens; they show that intensifying screens do record the scattered radiation less in proportion to the direct rays than plain duplitized films. The effect is not large, but enough to produce a noticeable increase in contrast. The use of double intensifying screens reduces the ratio of diffuse to total radiation from 4.3 to 3.4 a decrease of 21 per cent. In every case the double screen is seen to be slightly more effective than the single screen. The three types give practically the same results; the small differences may be attributed to experimental error. There is no doubt that part of the increased contrast given by intensifying screens is due to their lower relative sensitiveness to scattered rays. However, it is evident that intensifying screens are far from being a solution of the problem of scattered radiation inasmuch as they lower only slightly the proportion of scattered radiation reaching the film; they still leave much room for improvement. The experiments on contrast showed that a higher contrast could be obtained by reducing the intensity of scattered rays than by the use of intensifying screens. However, the gain in contrast produced by a reduction of the scattered rays can be enhanced by the use of intensifying screens, and the screens tend to offset the loss in *x*-ray intensity.

For the experiments in definition, a definition test object was made up of 16 wire gauzes ranging from 110 to 280 meshes per inch. The spacing of the meshes was measured with a micrometer microscope. Each gauze was about ¼ inch square and the whole set was mounted together between two squares of cardboard. The definition test object was radiographed at various distances from the film and with varying amounts of scattering material. A medium focus radiator type Coolidge tube was used, running at 60 kilovolts with a target film distance of 20 inches. The films were given the usual standard development of five minutes in Elon-hydroquinone developer at 65° F. The best definition obtainable under each set of conditions is recorded in Table IV. In some cases the finest gauze available, 280 meshes per inch, was not fine enough to test the limit of definition, and in these cases the result is indicated by >280 (greater than 280); in other cases, the coarsest mesh could not be resolved and the result is indicated by <110 (less than 110). The radiographs were examined with a small magnifier (10x) and the finest gauze whose meshes could be distinguished over its whole area was taken as representing the best definitions obtainable under the conditions of the experiment; special effort was made to maintain the same criterion of judgment in examining all the tests.

The differences between the definition with and without the water show the large effect produced by the scattering material. Probably part of the loss in definition is produced by selective absorption of the softer rays, but undoubtedly most of it caused by scattering. As the test object is moved away from the film, the definition is diminished by reason of the size of the focal spot, but it is reduced a great deal more by the scattered radiation.

When the test object is away from the film, the "undercutting" of the scattered rays has a serious effect upon definition, as is shown by the large differences in definition when the test object is next to the film and when it is 1 or 2 inches away. Reducing the intensity of the scattered rays by means of diaphragms produces a marked improvement in the definition.

Tests of the definition of intensifying screens made without scattering material have shown that their definition is much poorer than that of plain duplitized film.[2] It would be expected that in radiographing thick parts this difference would be much less marked and that the differences between various screens in definition would be even less noticeable.

To determine the effect of intensifying screens upon definition in radiographing through a scattering material, comparisons were made between various screens and duplitized film, using a variety of conditions to secure a wide range of definition values. The data from these experiments are re-

TABLE IV

| Distance of definition test object from bottom of tank | Depth of water (in inches) | Definition in meshes per inch: 20 inch image diameter | 4 inch image diameter | 1 3/16 inch diaphragm at surface of water | Definition with no scattering material |
|---|---|---|---|---|---|
| | 1 | >280 | >280 | >280 | |
| | 2 | >280 | >280 | >280 | |
| | 3 | >280 | >280 | >280 | |
| 0 | 4 | 280 | >280 | >280 | >280 |
| | 6 | 230 | >280 | >280 | |
| | 8 | 195 | 280 | >280 | |
| | 10 | 150 | 230 | >280 | |
| | 2 | 170 | 190 | 205 | |
| | 3 | 165 | 180 | 195 | |
| 1 | 4 | 155 | 170 | 190 | 280 |
| | 6 | 130 | 160 | 175 | |
| | 8 | 110 | 145 | 165 | |
| | 10 | <110 | 130 | ... | |
| | 4 | 110 | 120 | 175 | |
| 2 | 6 | <110 | <110 | 150 | 205 |
| | 8 | <110 | <110 | <110 | |

corded in Table V, for three types of screens, A, B, and D.

It will be noted that the differences in definition among the various screens and duplitized film show up under most of the conditions tried; but when the conditions are such that poor definition is obtained these differences become small, practically negligible, as is shown where the test object is 1 inch from the bottom of 6 inches of water. The better the definition, the more pronounced are the differences in the definition of the various screens.

In radiographing the thickest parts, where the portions of chief interest are usually some distance from the film, it would appear that the limitations of screens in the matter of definition are not of much importance; but where the conditions do permit of good definition, as for instance when it is possible to bring the portions of chief interest close to the film or when scattered radiation is considerably reduced by means of a diaphragm, then a screen having good definition is of definite advantage, and if the best possible definition is demanded, screens should not be used, provided, of course, that satisfactory immobilization can be secured. In reducing the intensity of scattered rays by a diaphragm the increase in exposure required makes it necessary in most cases to use intensifying screens; in order to secure the fullest advantage from the reduction in the scattered rays, the screens employed should have the best possible definition.

In the tests of the definition of the screens without scattering material, the various

TABLE V

| Distance of test object from bottom tank | Depth of water in inches | Definition: Duplitized film without screens | A single screen | A double screen | B single screen | D double screen |
|---|---|---|---|---|---|---|
| 0 | 0 | >280 | >280 | 280 | >280 | 230 |
| | 6 | 230 | 185 | 175 | 120 | 120 |
| | 2 | 170 | 155 | 150 | 130 | 115 |
| | 3 | 165 | 140 | 130 | 115 | 110 |
| 1 | 4 | 155 | 120 | 120 | 110 | 110 |
| | 6 | 130 | 110 | 110 | <110 | <110 |
| | 8 | 110 | <110 | <110 | <110 | <110 |

screens used were in the following order as regards excellence of definition:

1. A, single
2. B, single
3. A, double
4. D, double

When scattering material was interposed, the A double screen was found to have better definition than the B single, whereas the reverse was the case without scattering material. This observation seemed very peculiar, but several repetitions of the experiment gave the same result. The explanation of this fact will probably require a knowledge of the factors which govern the definition of intensifying screens, such as the sizes and distribution of the particles of fluorescent material and the scattering of light and *x*-rays within the fluorescent layer.

It is evident that tests of the definition of intensifying screens should include exposures made through a scattering material to determine the value of the definition of the screens under conditions of actual use.

In the matter of definition, also, it is found that intensifying screens have an effect upon the radiograph other than that of a reduction of scattered radiation; intensifying screens tend to give poorer definition than is obtained without them, while a removal of scattered rays improves the definition. The primary purpose of intensifying screens is to diminish the exposure, and in doing so they often assist greatly in overcoming the loss in definition from motion of the patient. Intensifying screens can be used with advantage in the examination of many types of cases and often they are essential for a successful radiograph. To point out their limitations, however, is not to disparage their value when properly used. The roentgenologist, with a knowledge of the characteristics of his screens and of the requirements of the case under examination, must decide in each case whether or not intensifying screens are likely to give the best result.

From this series of experiments, it is apparent that there is no adequate substitute for an actual reduction in intensity of the scattered radiation, other methods of increasing the contrast do not have the same effect as the removal of scattered rays, and do not give as much improvement in contrast or definition as can be obtained by a sufficient reduction of the scattered radiation. Most important of all, in the detection of faint differences in absorption, the removal of scattered radiation can give results far superior to any other technique.

The effects of tube voltage, filters, and intensifying screens upon the proportion of scattered radiation affecting the film indicate that the scattered rays are but little different in quality from the primary rays, and therefore there is no prospect of effectively separating the scattered rays from the primary rays by filters having a selective absorption, or by photographic materials having a special type of sensitiveness. The only method of reducing scattered radiation to any considerable extent is by the use of diaphragms. These may restrict the scattering by limiting the volume of material rayed, or they may be arranged, as in the case of the Bucky diaphragm, to prevent the scattered radiation from reaching the film.

Small cones or diaphragms placed between the tube and the scattering material are suitable for some experimental purposes, as in the present investigation, but they have only a limited application in practical radiography on account of the small sizes of radiographs they allow. What is required is a method of effectively reducing scattered radiation over a large area. The double shot method, developed by Dr. L. G. Cole, is illustrated in Figure 5. One slot in a large sheet of lead is above the scattering material, the other between the scattering material and the film. They are moved simultaneously in a horizontal direction, the two slots being kept in line with the focal spot which is stationary. The exposure is made through these two slots as they move along. Dr. Cole employed also a third slot near the tube to screen off radiation from other parts of the tube than the focal spot. He found that this method gave a considerable reduction of the intensity of the scattered rays and produced

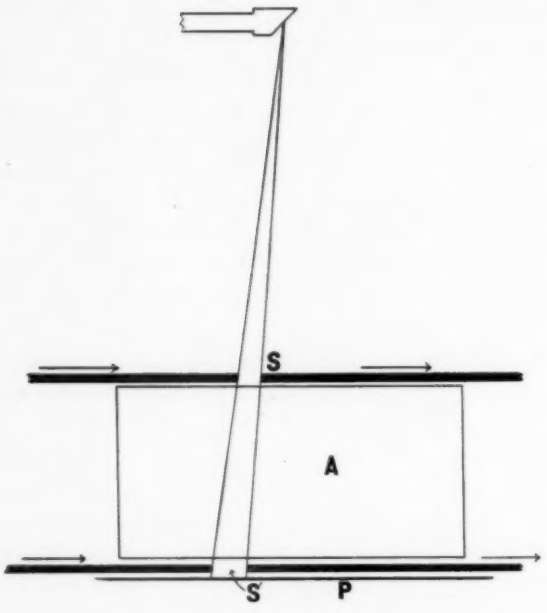


FIG. 5. Diagram illustrating the double slot method of reducing scattered radiation over a large area, the slots S and S′ in sheets of lead are placed above and below the scattering material as shown and are kept in line with the focal spot while being moved in a horizontal direction. The slot S′ moves between the scattering material A and the photographic surface P.

great improvement in radiographic quality. However the method required such heavy continuous exposures as to make it impracticable with the ordinary *x*-ray tubes. A water-cooled tube would be necessary to get a radiograph in one continuous exposure.

Dr. Potter's modification of the Bucky diaphragm[3] has proved itself to be a very practical method of reducing scattered radiation over a large area and has achieved a well-deserved popularity.* The remarkable results obtained with the Potter-Bucky diaphragm have done more than anything else to demonstrate the improvement afforded by a reduction of the scattered rays. There can be no doubt that it is the greatest advance in radiographic technique in recent years.

In conclusion, it must be pointed out that the increased exposure required when scattered radiation is reduced constitutes an additional source of danger. Greater care must be exercised to avoid an *x*-ray burn. The Potter-Bucky diaphragms now in use require about three or four times the normal exposure, which means that one third or one quarter as many radiographs can safely be taken as by the ordinary technique without the diaphragm. It is practically essential in most cases that intensifying screens be used with the Bucky diaphragm to reduce this danger.

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*An investigation of the efficiency of the Bucky diaphragm principle will be presented in an early issue of this Journal. This will show the influence of various factors in the design of the grid upon the effectiveness of the diaphragm.

# THE KEARSLEY STABILIZER*

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THE milliamperage which will pass through a hot cathode roentgen-ray tube increases very rapidly with the temperature of the filament and hence with the heating current. To avoid fluctuations in milliamperage, in all of the early installations a storage battery was used as a constant source of heating current. The storage battery called for a good deal of attention and was, for various reasons, far from ideal for the purpose. It has been almost completely superseded by the "filament transformer." This has been more convenient, but owing to line-voltage fluctuation, has resulted in greater variability in the milliamperage passing through the tube.

In an earlier article[1] the author has alluded to attempts to hold the filament current constant by means of magnetos, boosters, iron wire ballasts, and various other devices, and finally by means of a special constant potential transformer. The last named device had no time lag and functioned very well, but took a pretty heavy current—often 18 to 20 amperes.

The above efforts were all directed toward the suppression of fluctuations in milliampereage due to causes external to the tube itself. Even with constant filament temperature, changes in milliamperage may take place due to vacuum changes in the tube. Certain gases, when liberated from the electrodes or glass walls, will cause a diminution in the electron emission from the filament, and hence in the milliamperage.

Mr. W. K. Kearsley, Jr., has devised a stabilizer[2] which works on an entirely different principle and is much more ambitious in its aim. It does not attempt to hold filament current constant but, rather, automatically varies it as required to maintain constant milliamperage through the tube. It accomplishes this result regardless of line-voltage changes and regardless of internal vacuum changes. The following description of this stabilizer is taken from Mr. Kearsley's article:

"The stabilizer is operated directly by the high tension current which flows through the *x*-ray tube. Any change in this high tension current causes the stabilizer to act directly on the current flowing through the filament. If for any reason the high tension current through the tube tends to drop, the stabilizer immediately increases the filament current sufficiently to prevent the drop. The same holds true for a rise in high tension current; the filament current in this case is immediately lowered enough to keep the milliamperage at the desired value.

Figure 1 shows diagrammatically the principle upon which the stabilizer operates. A is an electromagnet which is connected directly into the high tension circuit. All of the high tension current passes through this magnet. B is an iron armature which is free to vibrate when current passes through the

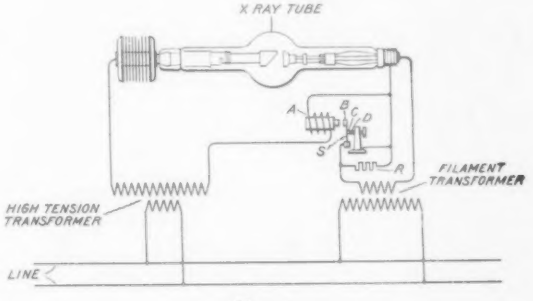


FIG. 1.

[1] A summary of physical investigation work in progress on tubes and accessories. AM. J. ROENTGENOL., December, 1915, p. 891.

[2] W. K. KEARSLEY, JR. A new type of stabilizer for use with the Coolidge tube. This was described by Mr. Kearsley in a paper read December 15, 1920, at the Chicago meeting of the Radiological Society of North America.

*Read at the Midwinter Meeting of the Eastern Section of THE AMERICAN ROENTGEN RAY SOCIETY, Atlantic City, N. J., January 28, 29, 1921.

magnet A. C and D are contacts. One of these is fastened to armature B and moves with it, while the other remains fixed. These contacts are in series with the filament in the *x*-ray tube. There is also a small fixed resistance R, which is connected across the wires leading to the contacts. S is a spring which pulls the armature away from the magnet.

The operation is as follows:

We will assume that a small current of say 1 or 2 ma. is allowed to flow through the tube and magnet A. This current exerts a pull on the armature B, but if the spring S is sufficiently strong the armature will not move. Now if the current is increased to say 10 ma. the magnet overcomes the tension of spring S, and the armature moves toward the magnet. The instant the armature moves, contacts C and D separate, and the current, which was flowing through these contacts to the filament, now has to pass through the small resistance R. This resistance immediately lowers the filament current, which, of course, keeps the high tension current through the tube from going higher. This operation is repeated for each cycle of high tension current passing through the tube.

It will be seen then that the high tension current through the tube is controlled by the tension of the spring S. If 20 ma. is desired instead of 10 ma. the tension of spring S is increased. More current now has to flow through the magnet before the contacts will separate. Instead of changing the tension of the spring to get more or less current through the tube, the magnet may be moved farther away from, or closer to, the armature B, which accomplishes the same result. The same result may also be accomplished by varying the number of turns employed, through the use of suitable taps, in the magnet coil.

Figure 2 shows another method of connecting the stabilizer to the tube circuits. In this case the magnet coil is connected to the center taps brought out from the high tension winding of the transformer, and the contacts C and D are inserted in series with the primary of the filament transformer.

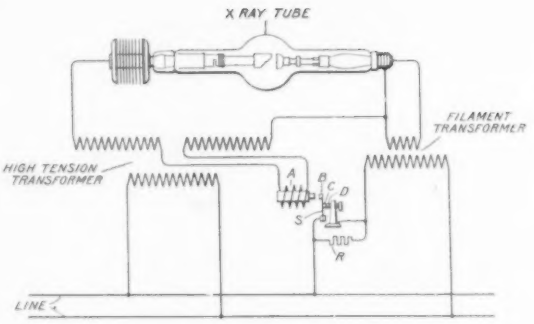


FIG. 2.

The operation is the same in either case. On those transformers having no leads brought out from the center point of the high tension winding, it is necessary to connect the stabilizer in the high tension lead to the cathode of the tube as shown in Figure 1. In this case the stabilizer becomes part of the high tension circuit.

Figure 3 shows an experimental model of the stabilizer.

Table I shows the effect of line-voltage variations on a tube without stabilizer, and the same tube with the stabilizer in circuit.

TABLE I

| *Without Stabilizer* | | *With Stabilizer* | |
|---|---|---|---|
| *Volts* | *Ma.* | *Volts* | *Ma.* |
| 77 | 2.2 | 70 | 2.00 |
| 80 | 3.3 | 77 | 2.00 |
| 82 | 4.3 | 84 | 2.05 |
| 84.5 | 6.0 | 87 | 2.05 |
| 86.5 | 7.0 | 90 | 2.05 |
| 89.5 | 8.4 | 93.5 | 2.05 |
| 91.0 | 10.0 | 96.5 | 2.05 |
| 92.5 | 11.5 | 99 | 2.05 |
| 95 | 13.8 | 103 | 2.05 |
| 96.5 | 15.0 | 106.5 | 2.05 |

The stabilizer in this case was set for 2.0 ma.

Table II shows how the stabilizer maintains the current through a radiator type tube during a long exposure. The tube was first connected to a filament control rheostat in the regular way and the current adjusted to 10 ma. Readings were then taken every half minute up to three minutes. The tube was then allowed to cool and the stabilizer connected in circuit. Current was adjusted to 10 ma. and readings were taken again.

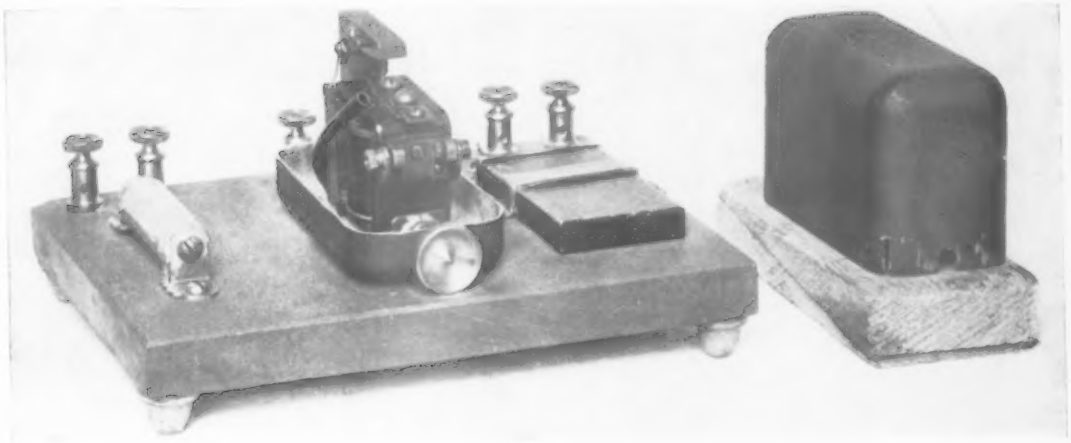

FIG. 3.

TABLE II

| *Without Stabilizer* | | *With Stabilizer* | |
|---|---|---|---|
| *Time* | *Ma.* | *Time* | *Ma.* |
| 0 Min. | 10.0 | 0 Min. | 10 |
| ½ | 9.6 | ½ | 10 |
| 1 | 9.3 | 1 | 10 |
| 1½ | 9.0 | 1½ | 10 |
| 2 | 8.7 | 2 | 10 |
| 2½ | 8.1 | 2½ | 10 |
| 3 | 7.0 | 3 | 10 |

Figure 4 shows curves made with an oscillograph. The tube was of the self-rectifying type. The lower curve represents a high tension current of 15 ma. through the tube and the upper one the filament current taken at the same time. The small irregular lines in the filament current curve show the points at which the stabilizer contacts opened to prevent a further rise in milliamperage through the tube. It will be noticed that there is a break in the filament current curve for each cycle of current through the tube. This shows that the vibrating armature vibrates in synchronism with the alternating current supplying the tube. This is important. If the armature did not vibrate in synchronism, the filament current would not be adjusted to the correct value on some of the cycles, which would cause a variation in the milliamperage through the tube.

That the stabilizer does produce an even flow of high tension current through the tube is shown by evenness of the peaks of the waves in the upper curve, which is the curve of the high tension current."

There are many applications which can be made of the new device.

It will make it easy to combine fluoroscopy with radiography, as, by means of the stabilizer and a suitable switch, the change can instantly and surely be made, even in the dark, from a fluoroscopic to a radiographic load.

It will eliminate one of the complications in the manipulation of a stereo-fluoroscope,

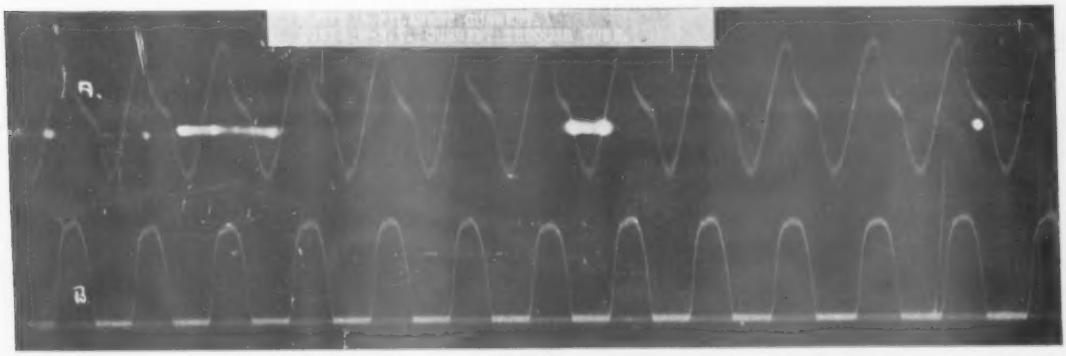

FIG. 4.

as, by its use, the two tubes can be made to maintain constantly and automatically the same millamperage.

It will increase the allowable radiographic load on a given size of focal spot. For it will make it unnecessary to test a tube and will in this way make it possible to start the actual exposure with a cooler target. It will, furthermore, render it unnecessary to allow a large factor of safety to guard against inaccurate adjustment of filament temperature and against inaccurate measurement of milliampereage.

It will be of great value in the administration of accurate dosage in therapy, especially where a technique is employed which involves a long time of treatment.

It should reduce puncturing troubles with both tubes and high tension generators, by reducing the surges attendant upon sudden changes in milliamperage.

It will be very helpful with direct-current installations where, with heavy loads, there has often been a marked drop in the alternating current voltage as the load came on the rotary. Where this drop is greater than can be safely handled by the stabilizer, a little booster can be added.

# A SUGGESTION FOR IMPROVING THE VISIBILITY OF THE APICAL FIELD ON THE CHEST RADIOGRAM*

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RAY BROOK, NEW YORK

THE lung markings in the apical field on the chest roentgenogram may be more or less masked by the shadow of the clavicle. This is an obstacle to the early roentgenographic diagnosis of tuberculosis, since in this disease the initial shadows usually appear at the apex.

The closest proximity of the lung apex to the plate at the time of roentgen-ray exposure is generally believed to be essential for the best definition of the apical lung markings. To this end the shoulders of the patient are brought in contact with the plate. The effectiveness of this procedure for the object desired is open to question. The apex of the lung is enclosed in the bony framework forming the upper aperture of the chest. This aperture is bounded anteriorly by the upper portion of the manubrium sterni. Consequently, once the tissues overlying this portion of the sternum rest on the plate, closer approximation of the lung apex to the plate is not possible owing to the inflexibility of the bony ring. The distance of the apex from the plate remains unchanged, irrespective of the position of the shoulders. To rest the shoulders on the plate necessitates their elevation, which in turn tilts upward the outer end of the clavicle, with the result that its shadow comes to lie across the apical field. Furthermore, the anatomical landmarks about the apex are disturbed, thus adding to the difficulty in correlating the physical with the roentgen-ray findings.

The accompanying illustration shows the patient in the position selected by us for increasing the visibility of the apical fields. The head is centrally placed, chin flexed, upper part of the chest in contact with the plate, shoulders lowered, the hands, with thumbs posterior, grasping the upper and outer part of the thighs, and the elbows rotated forward until they touch the table. Forward rotation of the elbows draws the scapulae outward so that their shadows lie outside the lung field. The patient in this position is directed not to raise the shoulders during the inspiration preparatory to the

*Read before the Saranac Lake Medical Society, November 24, 1920.

roentgen-ray exposure. Elevation of the shoulders is a natural but not necessary accompaniment of inspiration and will result in tilting the clavicles upward. The inspiration should be of moderate but not full depth, since the fuller the inspiration, the more the first rib tends to the horizontal, thereby diminishing the size of the apical field.

The accompanying roentgenograms of the same individual illustrate the position of the clavicular shadow in relation to the apical field with shoulders in the elevated and lowered positions.

With these points in mind, it has been possible for us to remove the clavicular shadow from the apical field in all but a few cases where it has not proven feasible because of anatomical peculiarities of the shoulder girdle.

FIG. 1.

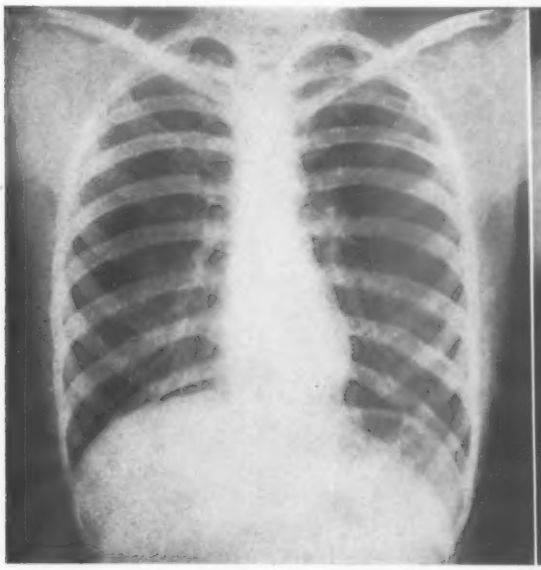

FIG. 2. Shoulders elevated. Clavicular shadow across the apical field, rendering difficult the interpretation of the lung markings in this region. Note the disturbance of anatomical relations, especially that of the outer end of the clavicle to the apical field.

Note: The relative position of roentgen-ray tube to patient and plate was identical for both exposures (Figs. 2 and 3).

FIG. 3. Shoulders lowered. Clavicular shadow horizontal and visibility of the apical field increased. The normal position of the anatomical landmarks about the apex is approximately maintained, thus facilitating the comparative study of physical and *x*-ray findings.

# A HISTOLOGICAL STUDY OF THE EFFECTS OF RADIUM ON CARCINOMA OF THE CERVIX*

By CHARLES C. NORRIS, M.D.
AND
NORMAN S. ROTHSCHILD, M.D.
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IN dealing with the treatment of cancer of the cervix by radium, let us consider first the clinical and pathological classifications. Ewing[1] has divided the condition into three stages: (1) A hard nodule in the substance of the cervical lip; (2) a circumscribed indurated ulcer of the portio or cervical canal, and (3) a non-diffuse low papillary outgrowth, covering a portion of the lip or canal. This classification holds true for the early cases of carcinoma of the cervix, which, however, unfortunately are rarely seen. He states that as usually observed the lesion is more advanced and exhibits first, an extensive induration and swelling of the cervix; second,an excavated ulcer, and third, extensive papillary or cauliflower outgrowths covering much of the canal and portio. Cullen[2] also classifies the condition into three stages: (1) Induration with loss of tissue; (2) disintegration, and (3) excavation. Another clinical classification is all important in the judgment of the treatment to be followed, and this classification is universally accepted by gynecologists using radium, the condition being considered, 1st, advanced, 2nd, borderline,and 3rd, early.

In the advanced and the borderline cases radium is effective in arresting the process, because of the fact that the pain is relieved, and bleeding and the foul discharges are stopped or considerably diminished. The improvement, however, takes place slowly, and discharge may be slightly increased the first week after the exposure. Further applications of radium may be required.

1. *Pathologically*, two types are found: (1) The squamous cell carcinoma of two varieties, basal cell and prickle cell, and (2) adenocarcinoma. Ewing has added the following atypical form: (1) Scirrhous carcinoma, (2) cystadenoma, (3) endothelioma, and (4) perithelioma.

Alter[3] has shown that the alveoli of basal-cell carcinoma in further proliferation take differing characteristic forms, so that in stages that are not too advanced it is easy to distinguish the following types: (1) Adenoid type, (2) solid type, and (3) cystic type.

Many factors are concerned in the effectiveness of radium on the malignant growth. Some cells may be radio-receptive, others radio-refractory. Colwell and Russ[4] have termed this selective absorption, while Dominici[5] has called it receptivity or sensitiveness. This idiosyncracy of the cells toward the rays depends first, on the life cycle of the cell. During mitosis it is more sensitive than in the resting stage. Mottram[6] has shown that the ascaris ova in mitosis are about eight times more sensitive than the resting cells.

2. *The Age of the Cells.* Immature, undifferentiated and embryonal cells possess a great affinity for radium, while mature cells and tissue have but a slight affinity. Embryonal cells as ova, spermatozoa and lymphoid cells are destroyed by the dosage of radium that would produce but slight reaction in the surrounding mature tissue. And the same has been observed in that the tissues of a child are more easily altered than those of an adult.

3. *Morphology and Function of the Cells.* Bergonis and Tirbondeau[7] believe cells vary in their reaction as they are definitely fixed or not in their morphology and function; for example, a neuroma is not very sensitive but is much more so than normal nerve. Testicu-

*Read by title at the meeting of the AMERICAN ROENTGEN RAY SOCIETY, Boston, June 15, 1921.

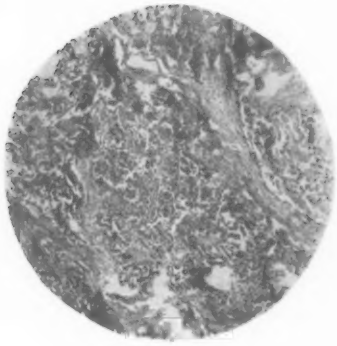

FIG. 1.

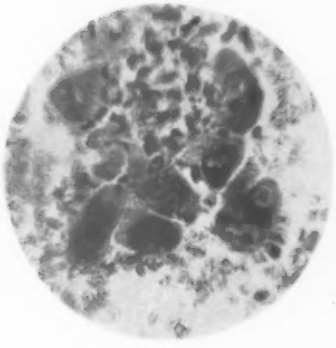

FIG. 2.

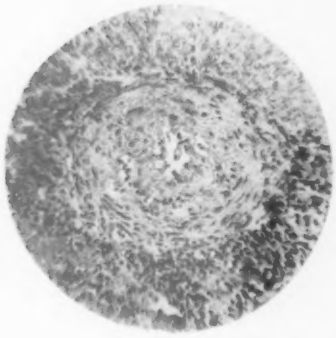

FIG. 3.

FIG. 1. High power. Section of squamous cell carcinoma, forty-eight hours after radiumization, showing edematous condition of the malignant stroma.

FIG. 2. High power. Showing malignant cells twelve days after radiumization with considerable increase in size. The nuclei show cessation of mitosis. The increase is noticeable in the size of the nuclei and the cytoplasmic substance.

FIG. 3. High power. The blood-vessels twelve days after radiumization, showing edema of all the coats, especially of the intima, with narrowing of the lumen.

lar island cells and spermatozoa are much less sensitive than the cellular layers they were developed from, and highly specialized cells like nerves, muscles, bone and cartilage, and red blood cells, all have a low radio-sensibility.

Wetterer[8] believes that the kind of cell damage is similar for all cells; it only differs in degree, varying as the quantity of absorbed rays, and as the specific radio-sensibility of the cell in question.

Let us note the various effects of radium rays upon normal tissue. The changes depend upon the length of the exposure and the infiltration of the rays. According to Knox,[9] slight exposure acts as a stimulant to the tissue, producing a congestion of the areas exposed, followed by an increased formation of fibrous tissue. If this exposure is prolonged or the infiltration insufficient, the action of the rays becomes a caustic one and an acute inflammatory process is set up,

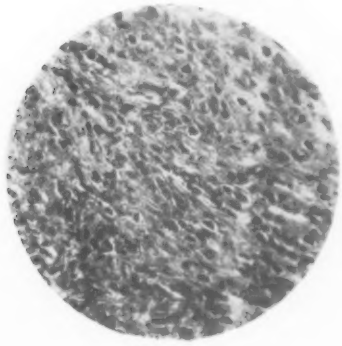

FIG. 4.

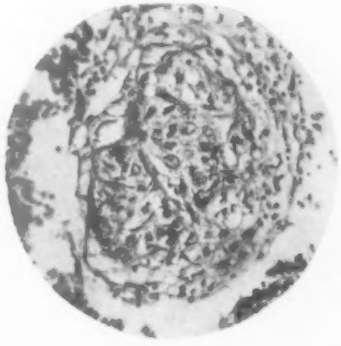

FIG. 5.

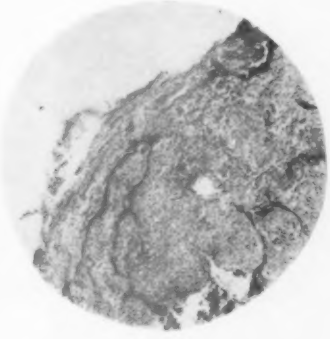

FIG. 6.

FIG. 4. Low power. Seven weeks after radiumization, showing fibroblasts infiltrating the malignant stroma and separating the malignant cells. The malignant cells are small in size and show evidence of destruction.

FIG. 5. High power. Eight weeks after radiumization, showing groups of malignant cells completely surrounded by fibroblasts. The malignant cells show destruction of the nuclei and vacuolization of the cytoplasm.

FIG. 6. Low power. Twelve weeks after radiumization, showing masses of chromatin in the fibrous connective tissue, the chromatin being the remains of the malignant cells.

which may go on to necrosis and sloughing of the tissue exposed.

When the exposure has been accurately calculated, the inflammation slowly subsides, the deeper tissues participating in the reaction of a diminishing ratio, according to their depth from the surface. There is in all the tissues an inflammatory condition, with a leucocytic migration and an invasion of small round cells. When this subsides, a fibrous tissue formation begins, and the newly formed connective tissue, with its capillary blood-vessels, may surround individual cells or areas of cells. By subsequent contraction and the cutting off of the blood supply to the isolated cells.

The histological effects of radium upon malignant tissue may be considered destructive and productive. By productive we mean the effects of the rays will produce tissue or cells which are not conspicuous in the histology of carcinoma or which appear in greater forces after the exposure.

We have divided the histological pictures into five stages.

1. *Stage of Acute Inflammatory Reaction.* This period embraces the first week after radiation and shows a congestion of the

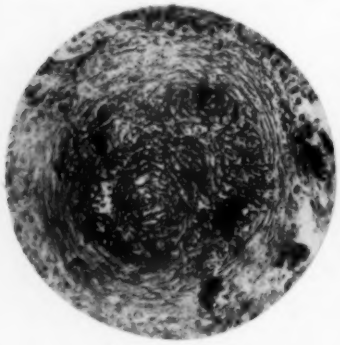

FIG. 7.

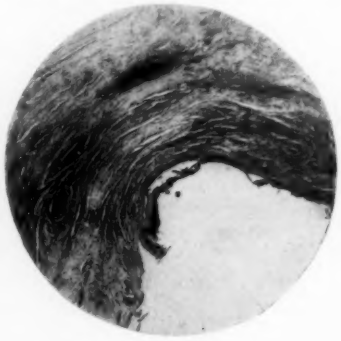

FIG. 8.

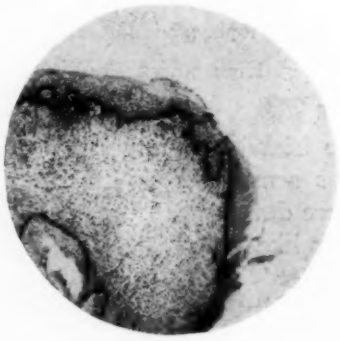

FIG. 9.

FIG. 7. Low power. The blood-vessels twelve weeks after radiumization, showing fibrosis of the intima and all the coats, with obliteration of the lumen.

FIG. 8. Fourteen weeks after radiumization showing complete destruction of the malignant cells in the fibrous field

FIG. 9. Low power. Sixteen weeks after radiumization, showing regeneration of the surface epithelium.

of the connective tissue, the blood supply to these areas is diminished. Changes of a varying degree, according to the rate at which the blood supply is restricted, will occur. If rapid occlusion of the blood-vessels takes place, local necrosis will quickly follow. If it is more gradual, atrophic changes may ensue. When a section from the tissues is examined, all these changes may be found taking place at the same time in various parts of the section.

From the foregoing, two points may be emphasized: First, that after the acute inflammatory process subsides, there is a production of new connective tissue, which isolates individual cells or groups of cells; and second, by the contraction of this fibrous tissue we have occlusion of the blood-vessels blood-vessels, exudation of lymphocytes and polymorphonuclear leucocytes, and a slight edema of the stroma. A slight swelling of the cancer cells is noted, also slight enlargement of the endothelium of the blood-vessels.

2. *Stage of Early Nuclear and Cytoplasmic Changes.* The second period embraces the second week and shows a gradual swelling of the cancer cells, an enlargement of the nuclei and relative increase of the cytoplasm. Mitosis in many instances ceases and the nuclear substance appears as granules. The cytoplasm, at times, shows vacuolization.

3. *Stage of Intercellular Changes.* At the beginning of the third week young fibroblasts are found scattered throughout the

radiated area. They infiltrate the malignant cells, dividing them into strands and in many instances completely surrounding groups of cancer cells and isolating them. The lymphocytic infiltration is increased in this stage, although lymphocytes and leucocytes have been present during the first two periods. The blood-vessels show edema of all the coats and especially of the intima, with almost complete obliteration of the lumen. At times leucocytes are present in the vessel wall.

4. *Stage of Destruction.* This period starts with the fourth week after the application of radium and continues to the ninth week. The nuclei of the malignant cells may be broken up and in many instances found as masses of chromatin, while, on the other hand, they may shrink and appear as an egg in a nest. The cytoplasm undergoes cytolysis. The group of cancer cells which have been isolated by the fibroblasts and connective tissue show a numerical reduction. The fibrous overgrowth at the end of this period is conspicuous. In its meshes the young blood-vessels at times show constriction of their lumen. The malignant cells throughout the entire field are considerably reduced numerically and in size.

5. *Stage of Healing.* In this final period the cancer cells appear as compressed bands in the fibrous stroma, only the small contracted nuclei remaining. At a later period no remains of the malignant cells are noted. Ultimately the surface epithelium shows regeneration.

The features of these changes are the changes of the malignant cells with their destruction and ultimate absorption and the replacement by fibrous tissue.

While the histological pictures have been divided into five stages, it must be acknowledged that the stages blend, and one may find many instances of early cellular changes with cells in the stage of destruction.

Caan[10] found the connective-tissue formation six to eight days after radiation when the malignant cells did not show any change. Finzi[11] believes the production of the connective tissue is the essential feature in the death of the malignant cell and destruction of the growth. Frank[12] believes that the rays cause the connective tissue to contract, with obliteration of the vessels and lymphatics and ultimate starvation of the malignant cells.

Ewing,[13] Schmitz,[14] Alter,[3] Wickham and Degrais,[15] and Dominici[16] have observed the cellular changes preceding the extensive fibroblastic injection. We are of the opinion that the effect of the rays caused the cessation of mitosis, destruction of the nucleus, vacuolization of the cytoplasm and ultimate death of the malignant cells.

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# A SIMPLE DRYING RACK FOR FILMS

By AMIN BOUTROS, M.D.

Roentgenologist to the Medical and Surgical Group of Denver

DENVER, COLORADO

WITH the transition from plates to films many of us were put to it to discover suitable substitutes for some of the conveniences of plate handling that were acquired by years of acquaintance with the plate. For example, I for one missed the plate drying rack, or rather, its substitute, and it was months before I hit upon a plan (now in use a year) that has so far proved quite satisfactory. At this late date it may prove of value to those who are still contriving drying devices.

It consists of a single dressed piece of 1¼ by 3 inch lumber. Three-sixteenth inch holes are drilled in its entire length, 2 inches apart and at an angle of 15 to 20 degrees, so that the holders are readily "hooked" in the holes of the rack as in Figure 1. The rack may be made any length desired and fastened over a sink or wash-tank or whatever other means are used to catch the drippings from the film.

In much the same way perpendicular holes can be drilled in a cabinet to store the holders while not in use, with the advantage of picking them out one by one without the loss of time caused by disentangling half the holders in your possession (Fig. 2).

FIG. 1.

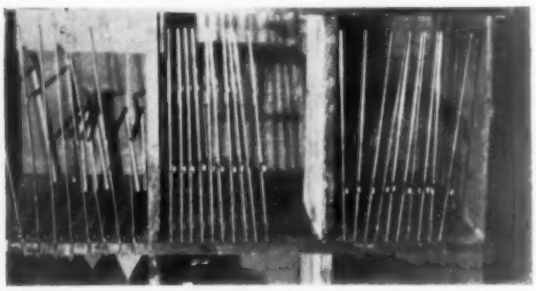

FIG. 2.

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*Issued Monthly. Subscription, $6.00 per year. Advertising rates submitted on application. Editorial office, 480 Park Avenue, New York. Office of publication, 67-69 East 59th Street, New York.*

*Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.*

## THE ANNUAL MEETING

The twenty-second annual meeting held in Washington the last week in September was in many respects the most successful in the history of the Society. The program included a full consideration of the most advanced problems before the *x*-ray world. With more than eight hundred registering, the sessions were always fully attended during the four solid days of program. The keynote of the meeting was "Deep Therapy," particularly as applied to carcinoma.

In a symposium on this subject, several of our foreign guests, Dr. René Ledoux-Le-Bard of Paris, Dr. Friedrich Dessauer and Dr. Hans Holfelder, both of Frankfort, presented in detail the underlying principles and they were supplemented by Dr. Samuel Stern, Dr. Wm. H. Stewart and Dr. Henry Schmitz, all of whom have made recent trips abroad and reported results. Although of necessity this symposium introduced highly technical problems, they were handled in as simple a manner as possible and were easily grasped by the listeners.

Scarcely less in interest was the symposium on therapy of the thyroid gland which embraced the toxic forms of goiter and carcinoma. This was presented by Drs. Geo. W. Holmes, A. F. Tyler, R. G. Allison, and G. E. Pfahler. Other therapeutic topics were therapy in skin diseases, which was discussed by Dr. H. H. Hazen of Washington, superficial malignancies by Dr. C. F. Bowen, interstitial radiation by Dr. Douglas Quick, brain tumors by Dr. H. C. Pancoast, diphtheria carriers by Dr. P. M. Hickey, and epithelioma of the cornea by Dr. D. Y. Keith.

The papers of Dr. W. D. Coolidge, Prof. J. S. Shearer, A. W. Erskine and Dr. Chas. L. Martin all consisted of scientific or experimental data which had a direct bearing on the basic factors in therapy.

Although much time was thus spent on therapeutic subjects, there was no lack of interest in the bountiful program devoted to diagnosis.

In the gastro-intestinal field, Dr. R. Walter Mills reported valuable observations on the small intestine; Dr. R. D. Carman discussed benign and malignant gastric ulcers; Dr. Jas. T. Case gave some collective results in pneumoperitoneum; Dr. L. G. Cole spoke on the differential diagnosis of certain duodenal bands, and Dr. A. H. Pirie showed how failures to cure by gastro-enterostomy could be sometimes turned into success after *x*-ray study.

Points on the diagnosis of sinus disease were brought out in the papers of Drs. G. E. Pfahler and J. G. Van Zwaluwenburg. Studies in pyelography were presented by Drs. Fred M. Hodges and W. L. Lim. Dr. Chas. M. Bowen and Dr. Willis Manges spoke on foreign bodies in the air passages, the latter limiting his remarks to the non-opaque bodies, for which he gave several new and valuable signs.

Topically unrelated, but interesting, were the papers by Dr. Myron D. Palmer who spoke on lesions of the spine, Dr. Edw. Blaine on Sprengel's deformity, Dr. Allen Scott Wolfe on dental radiography, Dr. H. M. Imboden on ossification of the meninges, and Dr. J. W. Pierson on pulmonary conditions in children.

A paper by R. B. Wilsey gave experi-

mental measurements as to the efficiency of the Bucky diaphragm principle. Among the new instruments presented were a new *x*-ray tube by Prof. T. E. Lilienfeld of Leipsig, a stereo-fluoroscope by Dr. J. D. Morgan, a simplified treatment unit by Dr. W. D. Witherbee, and a new oil-immersed unit by Dr. W. D. Coolidge.

In the executive sessions several changes were made in the constitution and by-laws, of which might be mentioned a clause requiring five years' practice in roentgenology before admission to membership, an increase in the annual dues, and an enlargement of the Executive Committee into an Executive Council. The Leonard prize was presented to Dr. A. J. Pacini and it was decided that it be offered again in the year 1923.

The guest of honor of the meeting was Dr. René Ledoux-LeBard of Paris, who delivered the Caldwell lecture. His address, "Progress of Deep Roentgen Therapy," was rendered in a pleasing and masterful manner and gave the members a valuable insight into foreign methods and results. Two of our other foreign guests, Drs. Dessauer and Holfelder of Frankfort, gave the German viewpoint on the same subject and contributed materially toward the success of the symposium on deep therapy.

The annual banquet on Thursday evening was given in honor of Dr. Frederick J. Baetjer, one of our oldest members. President Christie, as toastmaster, introduced Dr. René Ledoux-LeBard of Paris, Dr. Wm. S. Thayer and Dr. J. M. T. Finney of Baltimore, Mr. Geoffrey Pearce of London, and Dr. P. M. Hickey of Detroit, who toasted and roasted our dear old "Baetch" to the point where he responded in kind and in plenty. After it was estimated he had gotten even with Dr. Finney he was presented with a beautiful book containing hundreds of appreciatory letters from members and friends.

The Society gave a rousing vote of thanks to Dr. Christie and the local Committee for their successful arrangements and kindly entertainment, which included many enjoyable trips for the ladies. In the closing session it was announced that the 1922 meeting would be held on the Pacific Coast.

HOLLIS POTTER, Secretary.

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## A NEW PUBLICATION

*Acta Radiologica* is the latest periodical to appear in the radiological field. It is the official organ of the societies of Norway, Sweden, Denmark and Finland. Its articles are printed in French, German and English at the discretion of each writer, and it is edited by one of the foremost physicists and radiologists of the continent, Dr. Gösta Forssell. The editor visited the United States last year, and if one may judge the character of the Journal by its editor it will indeed occupy a lofty plane. Dr. Forssell has very kindly offered to send us abstracts of the articles appearing in the new Journal. Those of the first number appear in this issue. THE AMERICAN JOURNAL OF ROENTGENOLOGY extends a most cordial welcome to the newcomer in this most interesting field and hopes that its days may be long and its sphere of usefulness great.

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## AN ANTHOLOGY OF MALIGNANCY

The careless individual pays little attention to the insidious condition until he finds himself the unfortunate possessor of

A mass enormous! which in modern days
No two of earth's degenerate sons could raise.

*Pope*: The Iliad of Homer, Book XX, Line 337.

This, this is misery! The last, the worst
That man can feel.

*Pope*: The Iliad of Homer, Book XX, Line 106.

The patient then seeks the advice of a physician and—

Jove lifts the balances that show
The fates of mortal men, and things below.

*Pope*: The Iliad of Homer, Book XX, Line 271.

The physician seeks a consultation with the roentgenologist who greets the patient thus:

You go not till I set you up a glass
Where you may see the inmost parts of you.

*Shakespeare*: Hamlet, Act III, Scene IV.

This examination seems to reveal certain findings and the patient exclaims—

O thou, whose certain eye forsees
The fixed events of fate's remote decrees.

*Homer*: The Odyssey, Book IV, Line 627.

But the patient is not satisfied with the careful analysis and honest opinion of his physician and consultants and seeks advice from charlatans. After futile treatment and chimerical promises he finds that all he receives from them is—

The windy satisfaction of the tongue.

*Homer*: The Odyssey, Book IV, Line 1092.

Swallowing his pride, the patient returns to the physician he can trust and places his case without reservation in his hands, declaring—

Let him, oraculous, the end, the way,
The turns of all thy future fate display.

*Homer*: The Odyssey, Book X, Line 642.

The surgeon proceeds to remove the major portion of the malignancy and—

So ends the bloody business of the day.

*Homer*: Odyssey, Book XII, Line 31.

And the patient is bettered in his morale for we find that—

Hope springs eternal in the human breast.

*Pope*: Essay on Man, Epistle I, Line 95.

But after a period of time the surgeon begins to despair as one—

Who lined himself with hope,
Eating the air on promise of supply.

*Shakespeare*: Henry IV, Part II, Act I, Scene 2.

For is it not often the case that—

The miserable have no other medicine
But only hope.

*Shakespeare*: Measure for Measure, Act II, Scene 4.

But the surgeon then has an original (?) and happy thought, for he turns the perfectly hopeless case over to the roentgenologist, but very fortunately for the latter—

Blessed is he who expects nothing, for he
Shall never be disappointed.

*Pope*: Letter to Gay, October 6, 1727.

And fortunately for the patient this radiologic creature of circumstance and opportunity creates a new interest in the patient and his appetite increases, for he realizes that—

He must eat to live and live to eat.

*Fielding*: The Miser, Act III, Scene 3.

And again we find that—

Hope like a gleaming taper's light,
Adorns and cheers our way;
And still, as darker grows the night,
Emits a brighter ray.

*Goldsmith*: The Captivity, Act II.

And the patient finds that—

Appetite comes with the eating, says Augeston.

*Rabelais*: Works, Book I, Chapter V.

The radiologist earnestly at work discovers that—

It is not strength, but art, obtains the prize,
And to the swift is less than to the wise,
'Tis more by art than force of numerous strokes.

*Pope*: The Iliad of Homer, Book XXIII, Line 383.

But the day surely arrives when the radiologist is forced to admit that—

What cannot be cured must be endured.

*Rabelais*: Book V, Chapter XV.

And the patient—

All, soon or late, are doom'd that path to tread.

*Homer*: The Odyssey, Book XII, Line 31.

E. H. Skinner.

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## CORRESPONDENCE

*To the Editor*:

Dear Sir: I have read with a good deal of interest the article in your Journal recently by Dr. Pfahler with reference to his modified technique of the Erlangen method of roentgenotherapy. It was my privilege last year to visit this Clinic, as well as a number of others on the Continent, and I was impressed with the severity of the roentgen sickness that seemed the inevitable sequela of the treatment.

Since returning home I have been endeavoring to the best of my ability to mimic their methods, and there is one feature that I regard as being worthy of note, and that is the object of this letter.

In the constructing of this Department, it was bulit as a wooden addition to the Hospital. The building is set on posts, and at my request these posts were tarred, then a false floor laid, on the top of which was a two

and one-half inch layer of asphalt. The asphalt was made on the ground, as I insisted. I stood by to be sure that all the sand that went into it was practically burned before being incorporated with the tar to avoid as much as possible any moisture. On top of this asphalt layer there is an air space of two inches, then the ordinary wooden floor covered with battleship linoleum. In this way I think you will agree that the operator as well as the patient is pretty well insulated; in fact he is actually "off the world." The patient, of course, is on a wooden table.

Now, in spite of the fact that we have been giving intense treatments—some ranging three hours in duration with the full capacity of our apparatus (which I estimate to be 9¾ inches), using copper filtration, yet we have been fortunate in that roentgen sickness has not been present following this treatment in any case.

The argument that naturally occurs to one here is that we have not been giving the heavy treatment. In answer to this I would say that in the other Hospital (St. Joseph's) I have been giving treatments really less intense, and the radiation sickness has been extremely annoying.

I am bringing this forward hoping that it will evoke some comment or criticism, and in the hope that it is a means toward relieving this distressing condition.

L. K. Poyntz.

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## ON THE ELECTRICAL DANGERS IN X-RAY LABORATORY

*To the Editor:*

Dear Sir: Although not a physician, nor a roentgenologist, I regularly read THE AMERICAN JOURNAL OF ROENTGENOLOGY, and thereby increase my knowledge of that useful adjunct to the surgical and medical world.

My interest in such matters comes through the fact that for many years I have sold, installed and demonstrated to purchasing physicians, the use of modern, high-powered radiographic apparatus. I have visited the factories where such apparatus is made and have read all the articles on the subject which come to my notice.

In this way I read the article in your September, 1920, number entitled "Electrical Dangers in *X*-ray Laboratories" by J. S. Shearer, B. S., Ph.D., and I must confess to so strong a difference of opinion on one part of his article that I cannot refrain from addressing you in the hope that if I am wrong, you will show me just where. Naturally, it seems gross presumption for me to even suggest that such an eminent man as the author of that article could be wrong; nevertheless, though I have no titles to follow my name, I make so bold as to do so.

On p. 435, near the bottom of the second column, I read: "*But when placed on a grounded conducting table, danger is greatly increased,* quite contrary to traditional belief." (The italics are his own.) He goes on: "The path of least resistance from either terminal to earth is *from the terminal to the body*, thence to the metal table." (*These* italics are mine.) This statement surely is incorrect, for the following reason. The path of least resistance from either terminal to earth (if the tube stand is grounded, or the table, in the case of an attached tube stand) is from the terminal to the *nearest metal part of the tube stand.* There isn't a metal table on the market which would not have metal parts of the tube carriage nearer, by far, to the terminals of the tube, than *any part* of the patient's body would ever be. Therefore the path of least resistance, as I have said, would be from the terminal of the tube to the metal of the tube stand carriage.

It would of course be possible, by a very careless misadjustment of the tube above the patient, to cause one of the terminals to come closer to the patient than any of the metal parts of the tube stand, but I am not allowing such a supposition as that to be entertained, any more than I would brand street cars on our public streets as extremely dangerous simply because if one deliberately places himself in front of one of them while in motion, he will be killed!

Nor would there be any way to prevent a serious shock to a patient being radio-

graphed if he was timid, or nervous, or a child, or feeble minded, etc., as the author pointed out on page 437 and due preventatives were not used. When radiographing any such patients, the precautions mentioned in the article should be taken.

Therefore I am barring those two possibilities of danger from my treatment of the subject, since they properly are barred. I also am confining my statements to the assumptions that metal tables only are referred to, as they are in the part quoted. Any metals used in the construction of a table and its tube stand will be *far better* conductors than the human body. And since no radiograph would be made by an operator, who knew the first thing about his work, with one terminal of the tube pointed down close to the patient, *some metal part* of the tube carriage will *always* be nearer to the tube terminal than the body of the patient can be. How then does the rule of least resistance, quoted by the author, cause the current to seek the earth through the excellent airgap of insulation, the high resistance of the patient's body, and the metal of the table (which is grounded) *rather than* jump *directly* to that grounded metal which is *far nearer* to the tube terminal?

The next statement to which I take exception is in the sentence following that already quoted—"since the tube terminals are insulated from the stand in all cases." In other words, the current will find it easier to jump from ten to fifteen or more inches directly from the tube terminal to the patient's body, with the latter's high resistance added, and thence to the ground through the metal of the table, than to jump from *five to six inches* to the nearest part of the metal of the tube carriage, *which by the way*, is always *right in the very path* of a jump between the tube terminal and the patient. Why should the current deliberately overlook such a good ground as the grounded metal of the tube stand in its *bigger* jump to the patient through the air, which is one of the best insulators there is, when dry. So I would say that not only are the tube terminals insulated, as in the above quotation, but the *patient is as well*, through the large air gap separating the patient and the tube terminal.

My belief is that given a metal tube stand attached to a metal table, it is far safer to work with the table grounded than not grounded, which is exactly the opposite to the conclusions of Dr. Shearer; but I trust I have shown sufficient reasoning to give my contradiction the weight it must have to stand against such an authority as I am respectfully but none the less positively differing with.

As this is an extremely important question (the grounding or not grounding of radiographic metal tables having tube stands as an integral part) and as there are many workers using grounded tables, which, if more dangerous, should be warned to change, I would very much indeed be gratified to see this subject discussed again in the columns of your Journal. I feel that many practical workers and electricians will not agree with the author of the article referred to, and I hope you will *care to secure some other authorities to write on the subject.* It is not only interesting as an electrical and radiographic problem, but has the merit, if once and for all settled, of saving the lives of patients.

J. T. Warner.

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*To the Editor:*

Dear Sir: We have read with great interest the article by J. S. Shearer, B. S., Ph.D., on the electrical dangers in the *x*-ray laboratory, in the September issue of The American Journal of Roentgenology and are gratified to see the comment at the end of his article in which he refers to the leaflet published by us some time ago.

Evidently this leaflet is of some interest to the workers in your country, and we are pleased to note that most of the warnings which we issued, all of which apply in this country, apply in yours also.

We note that your contributor takes exception to one or two of the suggestions put forward, but we feel that perhaps he has

not quite appreciated our intention, or the possibility of different conditions prevailing in the two countries. In warning No. 3 it will be found we distinctly state that insulated wire should be treated with the same precaution as bare wire, which is contrary to encouraging any feeling of false security.

With regard to clause 5, we are in entire agreement with Mr. Shearer that tubing is far better for high tension overhead wires, but our warning was issued to the great many private installations and hospitals that have been installed for a number of years, and who are not prepared to scrap their present wiring and go to the expense of installing an overhead tubing system. No doubt in the course of time all installations will be fitted up with tubing to carry the high tension current. It was for the reason that we knew many of these installations had been up in use for a long time without attention that led us to add the extra precaution of grounded wires beneath the overhead cables, and most apparatus in this country is already fully protected against short circuitings which might occur if no special precautions were taken.

So far as paragraph 7 is concerned, we would like to point out that all our machines are already provided with circuit breakers, but we presume that the American machines are not so provided, and we feel that in spite of the vagaries of fuses, it is better to insert a fuse that is rated to blow at a definite current, rather than to have no fuse at all in the circuit. It is possible now to get a close guarantee with certain cartridge fuses; this practically eliminates the old trouble of fuse wire which can be considerably overloaded for disruption.

In reference to paragraph 8, this naturally applies equally well to all high vacuum tubes in the same way that it does to the Coolidge tube, the Coolidge tube only being mentioned as a well known example.

GEOFFREY PEARCE.

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*To the Editors*

Dear Sir: Were it not for the prevalence of some unfortunate ideas relative to rendering *x*-ray apparatus safe by grounding, the writer would hardly care to add to the previous discussion. However, where such misunderstandings exist, every effort should be made to clear matters up.

The letter of Mr. Geoffrey Pearce comes as a very pleasant reminder of a brief visit with him in London where some matters of mutual interest were discussed. I am quite sure he will agree that in any installation where a revision of high tension wiring and replacement by tubing would increase safety, the cost ought to be regarded as an insurance. Such systems may be made effective and yet be very inexpensive.

The matter of circuit breakers and fuses should be simple; we had better use *both*. Fuses have been in common use on American machines for years, but up to 1915 the writer does not recall seeing quick acting circuit breakers on standard *x*-ray machines. Since that time several makers have added them.

Mr. Warner's letter seems to show a little irritation; that, as is often observed, does not contribute to rational consideration of the subject.

The fourth paragraph of his letter raises a question of fact that may be easily disposed of by a little consideration. Mr. Warner states: "There isn't a metal table on the market which would not have metal parts of the tube carriage nearer, by far, to the terminals of the tube than *any part of the patient's body would ever be.*" The first answer to this statement is the simple record of death in the use of just the apparatus he mentions. The second is to consider actual stands and conditions as observed in practice. Measurements of the distance from tube terminals to the nearest metal of the stand show distances varying from 5 to 9 inches. Observation in hospitals and offices shows many cases where the tube terminals or live wires are nearer the patient than this. In kidney and ureter examinations with catheters in place, the distance to the elevated knees may be only a few inches; in dental work on a lower jaw the writer has observed operation at distances less than 5 inches on

several occasions. It is quite common to read of treatment at a 7 inch or an 8 inch target skin distance and the metal terminals will usually be as close to the patient as the target and may often be nearer. Experience has shown that one can not predict with certainty the path that will be selected by a sudden rush of current, but it does not tend to maintain a flow to insulators or to any extent to conductors when these are so well insulated that *no discharge path is provided.*

Paragraphs 7 and 8 are based on assumptions largely erroneous. The resistance of the human body does not count for much when we are dealing with the high voltages in use on *x*-ray tubes.

The resistance of the body may be as low as 5,000 ohms. If half the voltage used to operate a tube at a 5 inch gap is applied to the body and maintained, the current would be nearly 6 amperes. Cases are on record where contact with a circuit of less than 100 volts has caused death, although the current must have been less than 1/50 of an ampere.

Just how a patient on a grounded table in proximity to a high tension line from a transformer with a grounded point on its secondary, can be regarded as insulated, I am quite unable to understand.

We may have the body of a patient fully insulated from all portions of a high tension circuit or we may have *one* contact with such a circuit. The latter is the case when the patient is on a grounded metal table and the center of the secondary is grounded. Surely the maximum safety is secured when insulation of the patient is made as complete as possible. The only question to answer is, would the patient's safety be *increased* or *decreased* by the use of a grounded metal table as compared with the use of one well insulated or one made entirely of insulating material?

One should not discuss this matter on a basis of no unusual conditions or on the assumption that all operators are exceedingly careful at all times or that patients never move during an examination. The chance of too close proximity to the tube terminals or

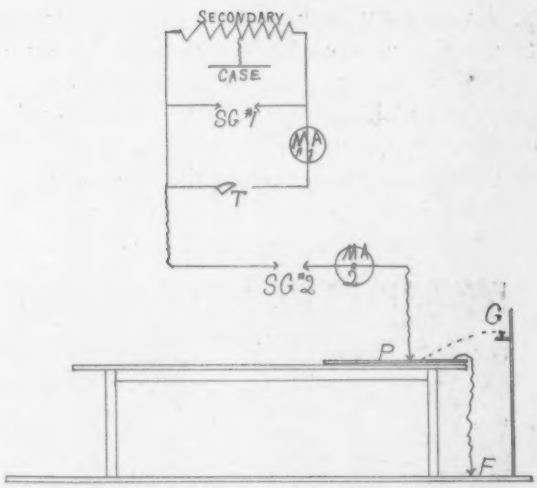


FIG. 1. S.G. No. 1. Spark gap on main circuit.
S.G. No. 2. Spark gap in series with M.A. No. 2.
M.A. No. 1. Measures tube current.
M.A. No. 2. Measures current to P.
F. Floor
G. Water pipe
P. Metal plate or pail of water.
The current through spark gap No. 2 flows from the outer end of one half of the secondary winding through the gap to the floor or ground, back to the case and thence to the inner end of the half of the secondary. High insulation between P and the floor or earth will effectually prevent such flow.

line is the *same* whether one is on an insulated table or on a grounded conducting table. The question reduces to simply this, *what are the relative chances of escaping serious injury in the two cases* if something unusual happens or when someone is closer than is intended?

No one informed on the subject is likely to deny that the larger the current maintained through the body for a given time the more serious are the results likely to be. We may easily test for the amount of current without using a patient.

A small metal plate or a pail of water may be placed on a dry wooden table and a spark gap and a milliammeter connected in series to one terminal of the tube. The plate or the water may then be regarded as related to the circuit in the same manner as the patient's body. When no connection is made from the conductor to the earth we have the case of a well-insulated patient. When a wire passes from the conductor to the floor we have a

partial ground. When the wire is connected to a water pipe we have a complete ground.

Figure 1 shows the arrangement of apparatus and Figures 2 to 5 are photographs of the set-up, showing some of the meter readings and the nature of the discharge.

The tube was excited by a transformer of standard make with the usual connection between the middle of the secondary and the case, but the case was not grounded by a conductor, it simply stood on a dry wooden platform. Under these circumstances there would be less current than when the case is well grounded. Spark gap No. 2 and milliammeter No. 2 serve to show how close a conductor must be brought to the line to get a discharge and the milliammeter shows what current flows when a discharge occurs.

Three conditions are considered:

(1) When the plate P is insulated.

(2) When a poor or partial ground is made by a wire to the floor. (In this case the wooden floor was laid on concrete.)

(3) When grounded by a piece of wire to a water pipe.

Not only were readings taken of the gaps and the currents passing, but flash light photographs were used to get instantaneous readings of the meters. A large electrostatic voltmeter in the background gave the high tension line voltage.

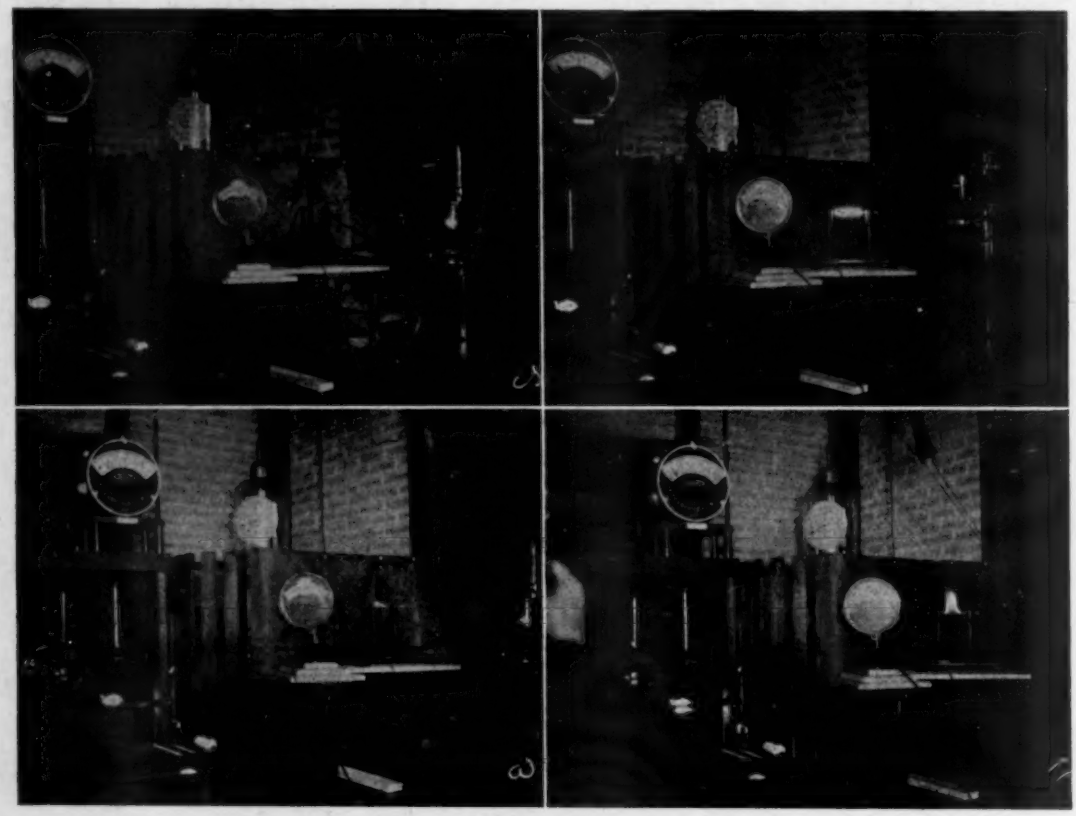

FIG. 2. 5 ma.; 8 inch spark gap; well insulated. Slight leakage across gap No. 2; too weak to photograph; not enough to deflect the milliampere needle.

FIG. 3. 3 ma.; 8 inch gap; resistance control; partial ground; spark discharge.

FIG. 4. 4 ma.; 5 inch gap; resistance control; partial ground.

FIG. 5. 5 ma.; 3 inch gap; auto-transformer control; complete ground; gap current exceeding 200 ma.

In each case, with no metal connection to the floor or pipe, there was no appreciable current to the plate even on direct contact, i.e., when spark gap No. 2 was closed.

Figure 6 shows the photographs of spark gap No. 2 with the data of tube operation at the time the discharge occurred. A scale

in inches placed just back of the gap was photographed at the same time and indicates the jumping distance from one terminal of the tube to the conductor under normal conditions of operation.

It should be remembered, however, that any irregularity of operation or especially the opening or failure of the filament circuit, either a partially grounded or a fully grounded conducting support.

The Table gives a few of the readings and conditions of operation.

When trying the same tests, using a transformer without a grounded middle on a setting of 5 ma. and a 9 inch gap, the passage of a spark through 2 caused a break of 14

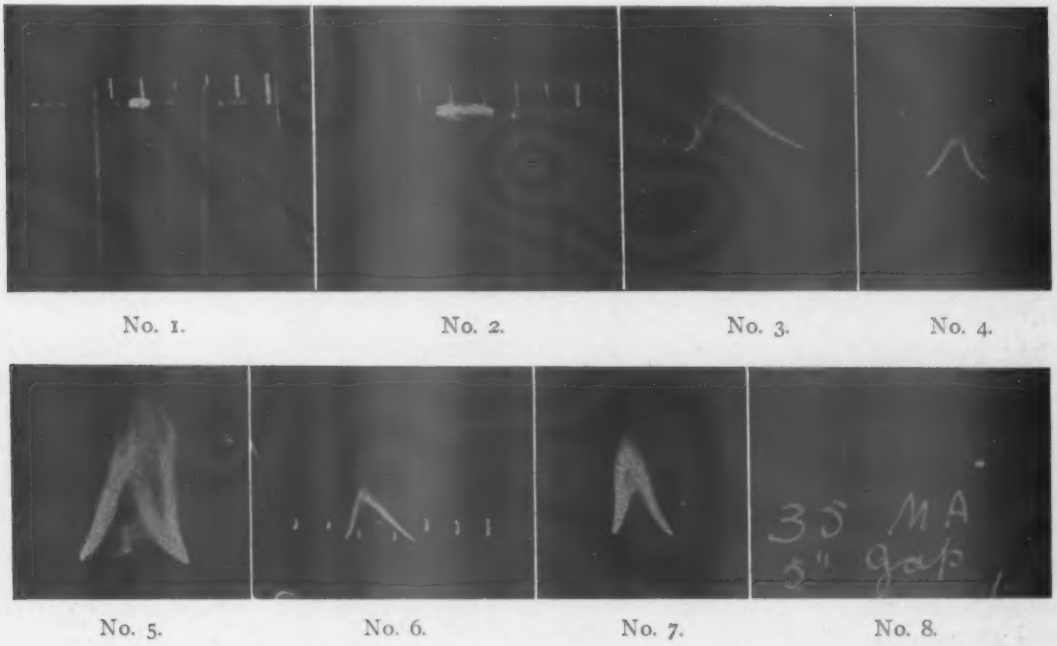


FIG. 6. Photographs of discharge across gap No. 2 under various conditions. Observe the insignificant spark discharge when plate is insulated. The most serious arc was on a setting for 5 ma., an 8 inch spark gap with an auto-transformer control.

No. 1. 5 ma.; 5 inch gap; resistance control; no ground. A series of sparks; current too small to measure.
No. 2. 5 ma.; 8 inch gap; resistance control; insulated. A series of sparks; current about 12 ma.
No. 3. 5 ma.; 8 inch gap; resistance control; grounded; current about 25 ma.
No. 4. 5 ma.; 8 inch gap; auto-transformer control; partial ground.
No. 5. 5 ma.; 8 inch gap; auto-transformer control; current more than 200 ma.
No. 6. 35 ma.; 5 inch gap; grounded; resistance control.
No. 7. 35 ma.; 5 inch gap; grounded; auto-transformer control.
No. 8. 35 ma.; 5 inch gap; insulated; resistance control.

or a cranky gas tube bringing surges into the line, would greatly increase this sparking distance and it may even exceed the full gap of the transformer at normal operation.

Figures 2 to 5 show some of the photographs by which readings were made. The actual current would vary somewhat according to the length of gap No. 2. When one realizes that only a few ma., often less than 50, may result fatally, it is quite clear that the insulated support is very much safer than

inches from the other high tension line, followed by an arc to the synchronous motor and a burn-out. In this case had *one* side of the line become grounded to any stand or table, a distance of 14 inches would not have protected the patient from the *other* line.

Clearly there can be no question that the patient's safety is much greater when insulated as fully as possible.

We may then summarize as follows:

1. Under all conditions of operation the

danger of a discharge to a patient is much less when he is completely insulated than otherwise.

2. The current passing to a patient by a spark discharge, or even by contact with one terminal when the patient is well insulated, is too small to show on the usual milliammeter. Note that a slowly acquired charge may give no sensation and is not a source of danger; a path to and from the body must be provided to cause death or injury.

3. Danger of spark or arc to the patient is rather greater when a resistance is used than with an auto transformer. Danger of spark over is much greater on closing the circuit than when operating steadily, and any spark over may be followed by an arc.

4. The current on break over resulting in an arc is always greater with an auto transformer.

5. Therapy at high gap should always be done with a transformer requiring a large series resistance and not with one using an auto-transformer control.

TABLE

| *Tube Current MA.* | *Working Gap or Voltage* | *Meter No. 2 MA.* | *Gap No. 2* | *Ground* | *Control* |
|---|---|---|---|---|---|
| 25 | 4½″ gap | 0 | ¼″ | none | Res. |
| | | 70 | 3″ | partial | Res. |
| | | 85 | 2″ | partial | Res. |
| 20 | 70 k.v. | 40 | 4″ | partial | Res. |
| 20 | 80 k.v. | 100 | 4½″ | partial | A.T. |
| 30 | 5″ gap | 200+ | 1¾″ | complete | A.T. |
| 30 | 5″ gap | 0 | 1½″ | none | Res. |
| 30 | 5″ gap | 80 | 1½″ | partial | A.T. |
| 30 | 5″ gap | 120 | 1½″ | complete | |
| 0 | 8″ gap | 18 | 5″ | complete | Res. |

Res. Resistance control; A.T. Auto transformer control.

The last reading illustrates surge gap on sudden interruption of current. The filament current was cut out and a break over of 5 inches or 1 inch more than half the working gap resulted.

Observe also that when a body is well insulated the currents resulting from small sparks are not large enough to give a milliampere reading.

6. The small 10 to 30 ma. transformers using no resistance are about as dangerous as large ones with auto-transformer control.

7. The safest operation when the patient must be between table and tube is secured by good insulation of table, stand and operator. Also when this is done the troublesome slight leakage discharge is eliminated.

8. Dental chairs are grounded and hence are dangerous for *x*-ray work.

As good insulation of patient and operator is the only guarantee of safety, we should endeavor to secure such installations as fast as possible.

J. S. SHEARER.

# TRANSLATIONS & ABSTRACTS

PANNER, H. J. On the *X*-Ray Examination of Duodenal Ulcer. (*Acta Radiol.*, 1921, 1, No. 1.)

The author gives a detailed account of the direct and indirect roentgenological signs of ulcer of the duodenum.

In roentgenological examinations of the duodenum the patient may be placed not only in the upright position but also in the recumbent position (dorsal, ventral and lateral positions). Too much importance should not, however, be attached to the *indirect* symptoms. The *direct* symptoms, the *deformity* of the bulbar-shadow, and especially *Akerlund's type*, are the best characteristic signs for the radiological diagnosis, and these seldom prove a source of diagnostic error, but the technique necessary to *obtain* them demands great experience and much patience.

SIMON, M. On the *X*-Ray Diagnosis of Gall-stones in the Common Duct. (*Acta Radiol.*, 1921, 1, No. 1.)

Cases of gall-stone in the lower end of the common duct, roentgenologically not directly visible as a positive shadow, but as a defect in the barium-filled duodenum. In the prone position the stone made an impression in the intestinal wall immediately above Vater's papilla.

KLASON, T. Hemophilia and Hemophilic Arthropathy. (*Acta Radiol.*, 1921, 1, No. 1.)

*References in Literature.* The writer has himself observed three cases of hemophilic arthropathies showing different stages. As characteristic of their *x*-ray picture, he states: In the early stages a cloudiness of the capsule from blood-clots and later decalcification, alteration of the cartilages and deformities, producing a hypertrophic arthritis deformans.

The knees are the most affected of all the joints, and besides the above mentioned alterations in the capsule and cartilages there are deformities and enlargements of eminentia and fossa intercondyloidea as the result of hemorrhages into the attachments of ligamenta cruciata genu.

STRÖM, S. A Case of Arthropatia Psoriatica. (*Acta Radiol.*, 1921, 1, No. 1.)

A case of arthropatia psoriatica with advanced destructive and atrophic changes of bones and joints in fingers and toes. The case indicates the affinity of the affection with bony changes of a neurogenic nature.

JOHANSSON, S. A Case of Osteogenesis Imperfecta with Extended Arteriosclerotic Changes. (*Acta Radiol.*, 1921, 1, No. 1.)

The author describes a case of osteogenesis imperfecta with multiple fractures, which is of special interest, as distinct arteriosclerotic changes in the arteries of the upper as well as of the lower extremities are shown on the *x*-ray plates. Histological examinations showed degeneration and calcification of the intima and media of the arteries. Thyreoidea and thymus markedly small. No similar case has been described, so far as the author is aware of.

HANSSON, H. A Case of Fracture of the Cranium with Accumulation of Air in the Cranial Cavity. (*Acta Radiol.*, 1921, 1, No. 1.)

The author gives an account of the cases of so-called "pneumatocele cranii" in the early and modern literature, and describes a *traumatic cyst in the right frontal lobe of the brain*, observed and roentgenographically examined by him, and containing air and liquid, which occurred in consequence of a fracture in the coronal area, penetrating the frontal sinus. The patient recovered without surgical treatment.

FORSSELL, GÖSTA. A Plateholder for Precise Roentgenography in Connection with Fluoroscopy. (*Acta Radiol.*, 1921, 1, No. 1.)

The article describes a new construction for centering and fixation of small plates on the site of a limited screen image by vertical fluoroscopy. The fluoroscopic screen is supported by an iron holder, framing a thin wooden plate. Guides are placed both on the

right and the left side on the holder, and these are connected with each other by a thin, horizontal steel wire, kept tense by a spring and movable vertically on the guides. A wooden ball is movable on the wire laterally. When the image is limited for roentgenography by fluoroscopy, the ball is placed just in front of it, the screen is removed and a cassette of convenient size is put behind the ball, which presses the cassette against the wooden plate framed by the screenholder. By this arrangement it is possible to make sharply limited plates very speedily during the vertical fluoroscopy.

HEIBERG, K. A., and STRANDBERG, OVE. Microscopic Examination of the Mucous Membrane of the Nose on Patients under Treatment for Lupus Vulgaris with Universal Arc-Light-Baths. (*Acta Radiol.*, 1921, 1, No. 1.)

Under the treatment with the universal coal-arc-light-baths reparative changes take place in lupus vulgaris of the mucous membrane of the nose.

The manner in which healing is brought about under the treatment with light-baths, is histologically seen to be even qualitatively different from the picture one meets with in the feeble spontaneous attempts at healing of the lupus vulgaris of the mucous membrane of the nose. Moreover, these examinations have shown that the healing of the mucous membrane of the nose in lupus vulgaris, which can be clinically proved under the above-mentioned universal light-bath treatment, is not a merely apparent healing, but a real healing process, histologically proved.

SIEVERT, ROLF M. The Distribution of the Intensity of the Primary Gamma-Radiation in the Neighborhood of Medical Radium Preparations. (*Acta Radiol.*, 1921, 1, No. 1.)

In consideration of the absorption and "dispersion," some formulas for the estimation of the gamma-ray intensity of the primary rays in various sources of radiation have been derived.

In order to utilize these formulas in radium therapy, some tables have been arranged. The relative intensities at different distances of a cylindrical radium preparation have been examined by means of an ionization method. The values observed correspond very well with the estimation. The secondary radiation of water has been measured after passage through about 1 mm. glass at a distance of .2 cm., and it was shown that this amounted to less than 2 per cent of the total intensity.

Dr. Lars Edling, lecturer in medical radiology in the University of Lund, in the first number of Acta Radiologica begins a richly illustrated article: *On Plastic Means of Application in Radium Therapy.*

Deep Radiotherapy and Its Realization with a French Apparatus. (*Arch. d'électric. méd.*, March, 1921, p. 69.)

(This is an unsigned article based upon information furnished by the Gaiffe-Gallot and Pilon Co., and by Dr. Dauvilliers of the Paris Laboratory of Physical Research.)

The apparatus described is one constructed by Gaiffe-Gallot and consists essentially of a Rochefort-Gaiffe coil feeding a tube immersed in oil contained within a completely closed lead box. It is well known that the coil furnishes a current of more constant voltage (at a low milliamperage) than does an interrupterless transformer and that with the same temperature in the anticathode a more homogeneous ray results. With the apparatus described, an equivalent spark-gap of 40 cm. measured between points, may be obtained, representing a voltage of about 200,000 volts. The inverse is suppressed by the introduction into the circuit of a kenotron. The tube carriage is swung from an overhead track, the high tension current being supplied by isolated vertical wires. The tube box proper is completely closed, filled with oil, and has lead walls 6 mm. thick. This thickness is sufficient to reduce the initial value of the rays $10^{-10}$. The rays escape through an aluminum window in the bottom of the box. Perfect protection from the rays and from the high tension current is claimed for both the patient and the operator. There is no appreciable ozone production. The circuit may be opened or closed, even at the maximum spark-gap without risk to the tube.

LOWELL S. GOIN.

JAPIOT, P., AND BUSSY, L. Radiotherapy in Interstitial Keratitis. (*J. de radiol. et d'électrol.*, v, No. 3.)

In spite of the pessimism of the past, radium

therapy has a definite place in ophthalmology. In the hands of the writers the *x*-ray treatment of interstitial keratitis has yielded particularly good results. All forms of parenchymatous keratitis are not equally suitable for treatment, hereditary and specific forms yielding more readily than others. Better results are obtained in young than in older subjects. The writers' best results were obtained in children from seven to ten years of age. In a girl eighteen years old progress was much less rapid. Treatment must be instituted as early as possible. Early treatment may succeed in aborting the disease, or at least the cure will be more complete and accompanied by much less opacity of the cornea. One of the most remarkable effects of radiation is the relief from pain and the prompt disappearance of the blepharospasm and photophobia.

There are two dangers to be avoided in the treatment of this condition; first, the destructive action of the rays on the eye itself and particularly on the juvenile eye in the course of development; second, the destructive action of the rays on the appendages of the eye. The destructive effect of rays on the eye has been disputed, some affirming the possibility of serious accidents and others denying this possibility. It seems to be a fact that these accidents are improbable in adults, even with large doses. But though negligible in adults, there is a real danger of injury to the eyes of children, a fact which induced the writers to use very weak doses in the treatment of interstitial keratitis, since it is a disease of childhood. The danger to the ocular appendages is more serious. The loss of the eye lashes and the occurrence of scar tissue on the free borders of the lids constitute a serious injury. The writers therefore limited the field of radiation to the cornea by employing as protection a sheet of lead pierced by an orifice the diameter of the cornea. The technique is described rather vaguely as consisting of the employment of a hard tube, 3 mm. of aluminum filtration, and an exposure of five minutes. The milliamperage is not stated. The writers estimate the total dose delivered to the ocular globe as 1½ H., or about ¼ H. at each séance. Five séances at intervals of one week constitute a series. One series is usually sufficient. The usual forms of therapy should be continued during the treatment. Two cases are reported in detail.

L. S. G.

WARNEKROS. The Third Stage of Labor in Roentgenograms. (*Arch. f. Gynäk.*, 1918, cix, 266. *Am. J. Obst. & Gynec.*, 1920, i, 319.)

To obtain accurate pictures of the placenta within the uterus it is necessary to inject immediately after the birth of the child, into the umbilical vein a sterilizable, opaque fluid. Warnekros found barium sulphate most useful. First blood is permitted to escape freely, so that rupture of placental vessels through overfilling is avoided. A short exposure of three to five-tenths of a second is sufficient. His observations permit the following deductions in regard to the mode and the time of detachment of the placenta: The placenta, as a rule, separates first at the edge, as always has been claimed by investigators in opposition to theorists. With but rare exceptions, the placenta reaches the internal os edgewise, and in this position glides into the vagina. Only in the vagina occurs the inversion which causes the placenta to appear outside the vulva exposing its fetal surface, or as customarily designated, in the Schultze mode. However, in a few pictures, the placenta was seen to detach first in its center, actually corresponding to the Schultze modus.

In accord with the more prevalent idea the separation of the placenta does not begin until the fetus is expelled from the uterus. Warnekros is forced to the conclusion that the detachment starts at the moment when the uterine muscle retracts over the escaping fetus, and is accomplished by the first few subsequent contractions, because in all his pictures, though taken within five minutes after the birth of the child, the placenta appeared completely detached. This was true even in forceps extractions, in which the general anesthesia probably had precluded strong contractions after the passage of the fetus.

Only in one instance could he photograph the placenta still in its normal attachment to the uterine wall. This was in a case of twins. Injection and exposure were finished before the second child had been born. The presence of the other fetus in the uterus, in his opinion, had prevented the retraction essential for the process of detachment.

This particular case, in his belief, also presents the strongest possible proof that the injection of fluid into the umbilical vein does not,

as has been claimed by some, actually cause the very quick separation of the placenta uniformly ascertained in his pictures.

WARNEKROS. Attitude and Mechanism of Expulsion in Breech Presentation. (*Arch. f. Gynäk.*, 1919, cx, 793. *Am. J. Obst. & Gynec.*, 1920, i, 319.)

Splendid roentgen pictures, presented in this article, show that also in breech presentations the fetus maintains a comfortable attitude, and that during labor the expelling force of the uterine fundus is actually transmitted by the vertebral column to the presenting breech. In Warnekros' belief this finally disposes of all objections raised by certain writers who have refused to accept the theory of such a transmission in pelvic end presentations.

WEIBEL. Study of the Third Stage of Labor in Roentgenograms. (*Arch. f. Gynäk.*, 1919, cxi, 413. *Am. J. Obst. & Gynec.*, 1920, i, 319.)

Out of forty-one attempts to photograph the placenta in the uterus, twenty-eight proved eminently successful. Weibel with some right claims priority over Warnekros in these studies of the third stage. The terms "Schultze" (more correctly Baudelocque) and "Duncan" mode of placental detachment must disappear from obstetric nomenclature. The actual mode of expulsion of the placenta from the vulva has no relation to the mechanism of its detachment. The opinion, still defended by some writers, that the separation begins during the stage of expulsion of the fetus, is untenable. In all normal labors, in which the final expulsion of the child is chiefly accomplished by abdominal pressure, the placenta is found in complete attachment at the moment of the expulsion. Detachment begins immediately afterwards, either at the edge or in the center, possibly in some instances simultaneously over its entire surface. In sliding down, the placental edge reaches the cervix first; occasionally this edge is seen bent over. The mode of its final appearance is dependent upon changes occurring during its passage through the vagina.

WARNEKROS. Spontaneous Change of Position of Full-Term Fetus During Labor. (*Arch. f. Gynäk.*, 1918, cviii, 475. *Am. J. Obst. & Gynec.*, 1920, i, 320.)

Two cases are represented in several roentgenograms, showing distinctly the spontaneous change of a breech presentation into normal head presentation in the course of the first stage of labor. This is the first graphic, and therefore unimpeachable proof for such a change of position which had been claimed as possible by clinical observations.

VOGT. Roentgenologic Proof of Extrauterine Life. (*Ztschr. f. Geburtsh. u. Gynäk.*, 1918, lxxx, 344. *Am. J. Obst. & Gynec.*, 1920, i, 320.)

This is a problem of great forensic importance. Efforts in this direction were first made by Vaillant. While in the living newborn, before he has received any nourishment, intestines and stomach are not visible in the *x*-ray picture, in the stillborn they are clearly visible. Similar investigations also had been made in regard to the lung pictures of stillborn and living newborn infants. Some investigators came to identical conclusions, others felt unable to concur in the findings. Vogt studied the problem on a very large material. He comes to the conclusion that the method is of some value if used critically, but is applicable only in cases in which no artificial resuscitation (especially swinging according to Schultze) had been attempted. The pictures must be taken very early before gases have formed as the result of beginning putrefaction. Otherwise grave errors cannot be avoided.